PROCEEDINGS

TWELFTH ANNUAL MEETING

NORTH CENTRAL WEED CONTROL CONFERENCE

DECEMBER 5-8, 1955

OMAHA, NEBRASKA

XUM

XUM

Proceedings

Twelfth Annual Meeting
of the
North Central Weed Control Conference

Omaha, Nebraska
December 5-8, 1955

OFFICERS

President—Buford H. Grigsby—Department of Botany, Michigan State University, East Lansing, Michigan.

Vice-President—Earl A. Helgeson—Department of Botany, North Dakota Agricultural College, State College Station, Fargo, North Dakota.

Secretary-Treasurer—Fred W. Slife—Department of Agronomy, University of Illinois, Urbana, Illinois.

COMMITTEE CHAIRMEN

Local Arrangements—D. W. Lambert

Program—N. E. Shafer
Research—D. L. Klingman
Extension—R. B. Widdifield
Regulatory—C. J. Gilbert
Industry—D. R. Weber
Terminology—L. G. Holm
Honorary Memberships—L. A. Derscheid
Future Meetings—E. K. Alban
Nominations—O. C. Lee
Resolutions—A. L. Bakke
Essay Contest—E. P. Sylwester

DIRECTORS

Alberta—G. R. Sterling—Department of Agriculture, Edmonton, Alberta
Illinois—F. W. Slife—University of Illinois, Urbana, Illinois
Indiana—G. F. Warren—Purdue University, Lafayette, Indiana
Iowa—L. Van Patten—Department of Agriculture, Des Moines, Iowa
Kentucky—J. F. Freeman—University of Kentucky, Lexington, Kentucky
Kansas—L. E. Anderson—Kansas State College, Manhattan, Kansas
Missouri—D. D. Hemphill—University of Missouri, Columbia, Missouri
Minnesota—R. E. Nylund—University of Minnesota, St. Paul, Minnesota
Michigan—B. H. Grigsby—Michigan State University, East Lansing, Michigan
Manitoba—H. E. Wood—Department of Agriculture, Winnipeg, Manitoba
Nebraska—J. D. Furrer—University of Nebraska, Lincoln, Nebraska
North Dakota—R. B. Widdifield, North Dakota Agri. College, Fargo, North Dakota
Oklahoma—Crawford Winton—Department of Agriculture, Oklahoma City, Okla.
Ohio—E. K. Alban—Ohio State University, Columbus, Ohio
Ontario—K. W. Hill—Department of Agriculture, Ottawa, Ontario
South Dakota—C. J. Gilbert—State Weed Board, College Station, South Dakota
Saskatchewan—T. V. Beck—Department of Agriculture, Regina, Saskatchewan
Wisconsin—L. G. Holm—University of Wisconsin, Madison, Wisconsin
Industry Representative—D. R. Weber—Spraying Systems Company, Bellwood, Ill.

DIRECTORS AT LARGE

O. C. Lee—Purdue University, Lafayette, Indiana
D. L. Klingman—University of Missouri, Columbia, Missouri
D. W. Lambert—Department of Agriculture, Lincoln, Nebraska
J. R. Foster—Experimental Farm, Indian Head, Saskatchewan
E. D. Jensen—University of Minnesota, St. Paul, Minnesota

XUM

Announcement of 1956 Meeting

Chicago, Illinois

December 10, 11, 12, 1956

Headquarters—Hotel Sherman

1956 OFFICERS

President—Earl A. Helgeson—Department of Botany, North Dakota Agricultural College. State College Station, Fargo, North Dakota.

Vice-President—Fred W. Slife—Department of Agronomy, University of Illinois, Urbana, Illinois.

Secretary-Treasurer—Dwight W. Lambert—Division of Noxious Weeds, Department of Agriculture and Inspection, State Capitol, Lincoln, Nebraska.

DIRECTORS

Albert—G. R. Sterling—Department of Agriculture, Edmonton, Alberta

Illinois—E. C. Spurrier—University of Illinois, Urbana, Illinois

Indiana—O. C. Lee—Purdue University, Lafayette, Indiana

Iowa—A. L. Bakke—Iowa State College, Ames, Iowa

Kentucky—J. F. Freeman—University of Kentucky, Lexington, Kentucky

Kansas—L. E. Anderson—Kansas State College, Manhattan, Kansas

Missouri—D. D. Hemphill—University of Missouri, Columbia, Missouri

Minnesota—E. D. Jensen—University of Minnesota, St. Paul, Minnesota

Michigan—G. P. Steinbauer—Michigan State University, East Lansing, Michigan.

Manitoba—H. E. Wood—Department of Agriculture, Winnipeg, Manitoba

Nebraska—J. D. Furrer—University of Nebraska, Lincoln, Nebraska

North Dakota—E. A. Helgeson—North Dakota Agri. College, Fargo, North Dakota

Oklahoma—Crawford Winton—Department of Agriculture, Oklahoma City, Oklahoma

Ohio—E. K. Alban—Ohio State University, Columbus, Ohio

Ontario—K. W. Hill—Department of Agriculture, Ottawa, Ontario

South Dakota—C. J. Gilbert—State Weed Board, College Station, South Dakota

Saskatchewan—T. V. Beck—Department of Agriculture, Regina, Saskatchewan

Wisconsin—D. R. Peterson—University of Wisconsin, Madison, Wisconsin

Industry Representative—Arne Carlson—E. I. Du Pont De Nemours & Co., Wilmington, Delaware

DIRECTORS AT LARGE

J. R. Foster—Experimental Farm, Indian Head, Saskatchewan

B. H. Grigsby—Michigan State University, East Lansing, Michigan

K. P. Buchholtz—University of Wisconsin, Madison, Wisconsin

G. F. Warren—Purdue University, Lafayette, Indiana

D. L. Klingman—U.S.D.A., University of Missouri, Columbia, Missouri

XUM

Preface

The Proceedings of the Twelfth Annual Meeting of the North Central Weed Control Conference are a record of the formal papers and reports of the Conference. Complete texts of all papers presented at the Conference are contained herein unless they were restricted or unavailable for publication. Additional copies of this Proceedings are available at $2.00 per copy as well as the Research Report of the Twelfth Annual North Central Conference from: Dwight W. Lambert, Secretary-Treasurer, North Central Weed Control Conference, Inc., P.O. Box 104, State Capitol, Lincoln, Nebraska.

XUM

Program and Table of Contents

Tuesday Morning, December 6, 1955

General Session, Civic Auditorium — **Chairman: Buford H. Grigsby**

Welcome to Omaha
Hon. John Rosenblatt, Mayor

Opening Remarks
Buford H. Grigsby, President—N.C.W.C.C. 1

Tuesday Afternoon, December 6, 1955

Section I. Botany, Physiology and Ecology — **Chairman: L. G. Holm**

The Surface Wax of Leaves
Robert H. Schieferstein and Walter E. Loomis
Iowa State College—Ames, Iowa 2

The Influence of Stage of Growth on the Control of Quackgrass with Maleic Hydrazide
Warren H. Zick and Kenneth P. Buchholtz
University of Wisconsin—Madison, Wisconsin 2

Plant Competition Studies with Field Corn and *Setaria* spp.
David W. Staniforth
Iowa State College—Ames, Iowa 3

The Distribution of Radioactive Amino Triazole in Plants
Bruce J. Rogers
Purdue University—Lafayette, Indiana 3

The Effect of 2,4-D on Tiba on an Auxin Transport Mechanism in Bean Stems
James R. Hay
Central Experimental Farm—Ottawa, Canada 4

The Translocation of Herbicides
George E. Barrier and Walter E. Loomis
Iowa State College—Ames, Iowa 5

The Inhibitory Action of a Garlic Extract on Starch Synthesis in Corn
Richard D. Hart, G. A. Gries, and B. J. Rogers
Purdue University—Lafayette, Indiana 5

Phyto-toxic Materials in Several Perennial Weeds
Earl A. Helgeson
North Dakota Agricultural College—Fargo, North Dakota 6

Preliminary Studies on the Germination of Weed Seeds
Bruce J. Rogers and Forrest W. Stearns
Purdue University—Lafayette, Indiana 7

The Influence of Light and Temperature on Germination and Flowering of Five Species of *Plantago*
Forrest W. Stearns
Purdue University—Lafayette, Indiana 8

Thio-Esters of N-Substituted Dithio-carbamic Acid as Selective Herbicides.
Philip C. Hamm, John J. D'Amico, and Marion W. Harman 8

The Effect of Potassium N-1-Naphthylphthalamate on the Geotropic Response and Growth of Corn, Pea and Oat Seedlings
Ching, Te May Tsou, Robert H. Hamilton, Robert S. Bandurski, Buford H. Grigsby, and G. B. Wilson
Michigan State University—East Lansing, Michigan 9

Absorption and Translocation of Radio-Active 2,4-D in Certain Weed Species
M. C. Williams, F. W. Slife, and J. B. Hanson
University of Illinois—Urbana, Ilinois 10

Section II. County Regulatory Meeting — **Chairman: John R. Reid**

How to Bring About a Better and More Uniform Enforcement of the Weed Laws
Charles J. Gilbert
South Dakota State Weed Board—College Station, South Dakota 11

Section II Continued. Regulatory and Extension — **Chairman: C. J. Gilbert**

Canadian Seed Grain Surveys
T. V. Beck
Department of Agriculture—Regina, Saskatchewan, Canada 13

XUM

State Weed Laws in Action
Vernon W. Woestemeyer
Department of Agriculture—Topeka, Kansas 14

Teaching Aids
Keith Wallace
South Dakota State College—College Station, South Dakota 16

What County Agents Expect
Walter E. Spilker
University of Nebraska—Lincoln, Nebraska 17

Section III. Engineering Developments and Agricultural Aviation **Chairman: Russell E. Larson**

Report of Studies of a Metering Device and Venturi Type Distributor for Agricultural Aircraft
James E. Henry
Ohio State University—Columbus, Ohio 19

Installation and performance of a Hydraulic Drive in a Piper PA-18A
Neal E. Shafer
University of Nebraska—Lincoln, Nebraska 19

Effect of Pesticides on Spray Equipment
Donald T. Black
Agricultural Engineering Research Branch A.R.S., U.S.D.A., Toledo, Ohio 21

Laboratory Apparatus for Studying the Design and Performance of the Rotary Hoe
Louis A. Liljedahl and John Strait
Division of Farm Machinery U.S.D.A.
University of Minnesota—St. Paul, Minnesota 22

Tuesday Evening

Banquet—Ball Room—Hotel Fontenelle

Toastmaster—George Round, Director of Public Relations, University of Nebraska—Lincoln, Nebraska

Banquet Speaker—Mr. Dave Livingston, America's Funniest Farmer—Washington, Iowa—"Let Us Spray"

Directors Meeting—West Room—Hotel Fontenelle

Wednesday, December 7, 1955

Section I. Weed Control in Field Crops **Chairman: L. H. Shebeski**

The Effect of Several Chemicals Applied in the Fall For the Control of Wild Oats
George Friesen
University of Manitoba—Winnipeg, Manitoba, Canada 22

MCP vs. 2,4-D for the Control of Weeds in Grain Crops
H. A. Friesen
Department of Agriculture, Experiment Station—Lacombe, Alberta, Canada 23

The Effect of Isooctyl Ester of 2,4-D on Eight Varieties of Oats
Paul F. Sand and Neal E. Shafer
University of Nebraska—Lincoln, Nebraska 24

The Effect of Wild Mustard Removal by MCP or 2,4-D at Various Stages of Growth of Wheat, Oats or Barley
L. H. Shebeski
University of Manitoba—Winnipeg, Manitoba, Canada 25

Laboratory and Field Studies With Several A-Chloroacetamides and Chlorallyl Dithiocarbamates on Corn and Soybeans
Fred W. Slife
University of Illinois—Urbana, Illinois 26

Control of Certain Annual Grass Weeds in Corn
David W. Staniforth
Iowa State College—Ames, Iowa 27

Control of Hairy Chess, *Bromus commutatus,* Schrad, in a Warm Season Pasture
M. K. McCarty and Paul F. Sand
Weed Investigations Section, U.S.D.A.—Lincoln, Nebraska
University of Nebraska—Lincoln, Nebraska 28

An Appraisal of Chemical Weed Control in Field Crops
H. E. Wood
Manitoba Department of Agriculture—Winnipeg, Manitoba, Canada 29

Retention of High Rates of 2,4-D in the Soil
Henry R. Keyser
University of Nebraska—North Platte, Nebraska 30

XUM

Field Experiences in 1955 with Defoliating Chemicals as an Aid to Harvesting Dry Edible Beans
Leslie R. Reed
Chipman Chemical Company—Bound Brook, New Jersey 32

Section I. Continued—Perennial Weed Control **Chairman: W. M. Phillips**

Response of Canada Thistle *Cirsium arvense* to Amino Triazole
Oliver C. Lee
Purdue University—Lafayette, Indiana 35

Controlling Canada Thistle With Late Fall Treatments of Herbicides
G. F. Ham, D. D. Bondarenko, and C. J. Willard
Ohio State University—Columbus, Ohio 36

Amino-Triazole in Controlling Perennial Weeds
Thomas K. Pavlychenko
American Chemical Paint Company—Saskatoon, Saskatchewan, Canada 37

Chemical Control of Texas Blueweed
A. F. Wiese and H. A. Rea
Texas Agricultural Experiment Station—Bushland, Texas 39

Chemical Control of Johnson Grass
L. E. Anderson
Kansas State College—Manhattan, Kansas 39

The Influence of Nitrogen Fertilization on the Control of Quackgrass With Herbicides
W. H. Zick and K. P. Buchholtz
University of Wisconsin—Madison, Wisconsin 40

Competition, Cultivation, and Chemicals to Eliminate Leafy Spurge
Lyle D. Derscheid, Keith E. Wallace and Russell L. Nash
South Dakota State College—College Station, South Dakota 42

Effect of Soil Sterilants on the Wind Erodibility of Pullman Silty Clay Loam
A. F. Wiese and H. E. Rea
Texas Agricultural Experiment Station—Bushland, Texas 44

Section II. Horticultural Crops **Chairman: E. T. Anderson**

Pre-Emergence Herbicide Treatments on Lima Beans, Snap Beans, and Sweet Corn
C. C. Singletary and J. W. Herron
Kentucky Agricultural Experiment Station—Lexington, Kentucky 45

Growth of Cucumbers, Corn, Field and Snap Beans Following Chemical Sprays for Control of Quackgrass
B. H. Grigsby, S. K. Ries, B. R. Churchill and R. H. Hamilton
Michigan State University—East Lansing, Michigan 46

Some New Possibilities for Weed Control in Carrots
G. F. Warren
Purdue University—Lafayette, Indiana 47

Pre-Emergene Weed Control in Potatoes in Mexico's High Mountain Valleys
Lowell S. Gleason, Jorge Nieto, and Julian Ramirez
Rockefeller Foundation—Mexico City, Mexico 47

Weed Control Around Newly Transplanted Apple Trees
Delbert D. Hemphill
University of Missouri—Columbia, Missouri 49

Weed Control in Strawberries
J. W. Herron and C. E. Chaplin
Kentucky Agricultural Experiment Station—Lexington, Kentucky 49

Weed Control in Wisconsin Cranberry Marshes
Malcolm N. Dana
University of Wisconsin—Madison, Wisconsin 50

Chemical Growth Suppression of Nursery Companion Crops
L. C. Chadwick and W. D. Chambers
Ohio State University—Columbus, Ohio 51

Mixtures of Herbicides for Nursery Weed Control
LeRoy G. Holm and Ray Taylorson
University of Wisconsin—Madison, Wisconsin 51

Tolerances of Certain Nursery Stock to CMU and SES
L. C. Chadwick and P. A. Barker
Ohio Agricultural Experiment Station—Wooster, Ohio 52

Chemical Weed Control in a *Taxus* Nursery
L. C. Chadwick, P. A. Barker, and W. D. Chambers
Ohio Agricultural Experiment Station—Wooster, Ohio 52

XUM

Chemical Control of Crabgrass in Lawns, Golf Greens, and Other Turfgrass Areas
H. L. Lantz
Iowa State College—Ames, Iowa 53

Studies on the Control of Crabgrass in Bluegrass Lawns
R. E. Nylund and Richard Stadtherr
University of Minnesota—St. Paul, Minnesota 53

Weed Control in Transplanted Tomatoes
G. F. Warren
Purdue University—Lafayette, Indiana 55

The Post-Emergence Application of Herbicides to Tomatoes at Different Times and Locations
S. K. Ries and B. H. Grigsby
Michigan State University—East Lansing, Michigan 55

Elimination of Vegetation With TCA and Dalapon
L. C. Chadwick and W. D. Chambers
Ohio Agricultural Experiment Station—Wooster, Ohio 57

Effects of 2,4-D on Concord Grape
Earl W. Scholz, W. E. Loomis, and H. L. Lantz
Iowa State College—Ames, Iowa 57

Soil Sterilization With Vapam and Sodium Chlorate
L. C. Chadwich, P. A. Barker and W. D. Chambers
Ohio State University—Columbus, Ohio 57

Section III. Woody Plant Control and Control of Vegetation on Non-Agricultural Land Chairman: L. L. Coulter

Wildlife Habitat Development With Herbicides in Michigan
B. C. Jenkins
Michigan Department of Conservation—Lansing, Michigan 58

Control of Undesirable Plants in Waterfowl Projects
R. A. MacMullan and E. M. Harger
Michigan Department of Conservation—Lansing, Michigan 58

Some Biological, Technical, and Administrative Aspects of Aquatic Weed Control in Minnesota
Edward J. Longtin
Minnesota Department of Conservation—St. Paul, Minnesota 59

Further Studies on the Use of Dalapon for the Control of Cattail
B. H. Grigsby, C. A. Reimer, and W. A. Cutler
Michigan State University, The Dow Chemical Company, and Michigan State University, respectively 60

Chemical Weed Control on Ohio's Highways
W. J. Garmhausen
Ohio Department of Highways—Columbus, Ohio 61

Performance of Erbon for Extended Vegetation Control in the North Central States
R. L. Warden and J. H. Davidson
Dow Chemical Company—Midland, Michigan 62

Effect of Cutting and Herbicidal Treatment on Control of Oak Sprouts
Harry M. Elwell and Maurice B. Cox
Field Crops Research Branch A.R.S., U.S.D.A., Guthrie, Oklahoma 63

Data on the Use of the Handgun for Basal Applications for Brush Control
Russel E. Larson
Agricultural Engineering Research Branch A.R.S., U.S.D.A., Columbia, Missouri 63

Thursday Morning, December 8, 1955

Farmers' Day Program **Chairman: Mal Hanson**

Are We Getting the Job Done in Weed Control
Charles J. Gilbert
South Dakota State Weed Board—College Station, South Dakota 64

How We Control Weeds on the Farm—Panel Discussion 66
Moderator, John Furrer
Lyle Derscheid—Agronomy Department—South Dakota State College, College Station, South Dakota
Howard Wahlgren—Elk City, Nebraska
Ray Beerman—Dakota City, Nebraska
W. L. Reichelt—Dunlap, Iowa

The Farmer's Chemical Kit For Weed Control
E. P. Sylwester
Iowa State College—Extension Service—Ames, Iowa 67

XUM

Thursday Afternoon, December 8, 1955

Farmers' Day Program — **Chairman: Bill MacDonald**

Are You Killing Your Bindweed? Why Not?
W. M. Phillips
Field Crops Research Branch A.R.S., U.S.D.A., Fort Hays Experiment Station—Hays, Kansas 70

What Is the Future in Weed Control?
L. M. Stahler
Agricultural Research and Development Division, Pacific Coast Borax Company—Los Angeles, Calif. 73

Weed and Brush Control in Pastures
M. K. McCarty
Field Crops Research Branch, A.R.S., U.S.D.A., University of Nebraska—Lincoln, Nebraska 74

Recommendations of Research Committee N.C.W.C.C. 77

Recommendations of the Committee on Terminology 90

1955 Weed Essay Contest Winner 91

Resolutions 92

Presentation of Awards 94

Registration List 95

List of Member Commercial Organizations as of November 16, 1955 105

List of Exhibitors 106

XUM

OPENING SESSION, 12th ANNUAL MEETING OF NCWCC

B. H. Grigsby[1]

Fellow members, guests and friends of the NCWCC: I consider it a privilege and real pleasure to welcome you to this, the 12th annual meeting of the Conference.

Those who have preceded me in opening annual meetings generally have seen fit to briefly remind the group of the history of this organization, to present a progress report and to speculate about the future of the group. In these brief remarks I should like to take a little longer look at our past because of the fact that we now, for the first time, have returned to the site of a previous annual meeting.

In terms of life history, and who should be more conscious of life history than we as weed workers, we are now at the birthplace and 12th birthday of the NCWCC. The idea was conceived at another place but the first breath was drawn here in 1944 and 90 individuals registered for the first session. These registrants were grouped as follows:

Regulatory	20
Research	20
Extension	16
Commercial	14
Farmers	2
Misc.	20

Compare that number and distribution with the last meeting at Fargo and with the present group.

In one of the reports presented at the first meeting a number of current problems needing immediate attention were presented and I have listed them as follows:

1. Bindweed.
2. Aquatic weeds in drainage ditches and shallow water.
3. Brush and small trees.
4. Herbaceous pasture weeds.
5. Right-of-way weeds and brush.
6. Annual weeds.

In another report, the field of herbicidal chemicals was discussed and the shape of things to come was sketched. In the list of chemicals were these: sulfur compounds, including mercaptans; acetic acid derivatives, including 2,4,-D; chlorinated hydrocarbons chlorinated and nitrated phenols.

The research committee report of the first meeting listed 17 important developments of the preceding 20 years and presented six fundamental problems, as well as 17 practical problems, which should be investigated. Time does not permit an enumeration of those 17 pressing problems but I am sure that 14 of them are still receiving considerable attention by a much larger group of workers than were present at the 1944 meeting. This is in no way intended as a criticism of the efforts made in the past decade but is a tribute to the sound and logical thinking of the initial group.

Of necessity, much of the research done in the scope of this conference has been directed toward rapid solution of the large number of practical problems. Results from such research have been translated into action programs by the Extension and Regulatory sections of the Conference. These groups are responsible to a great extent, for bringing weed control to the point where in 1955, about one of every ten acres of agricultural land was sprayed. Able assistance has come also from the various industrial organizations who have a vital interest in weed problems. In 1954, $48,000,000 was spent by farmers alone for weed control as well as large expenditures made by utility, highway, railway, and recreational groups.

These applications represent progress and are the result of coordinated effort by all agencies. The voluminous weed control literature stands as mute testimony of work done since 1944. Examination of this literature reveals the important fact that the fundamental side of chemical weed control has not been carried along at the same rate as the practical aspects. This will, in the long run, be a limiting factor and contribute to slower progress of the fight against weeds. Consideration of the primary objectives of regulatory, extension and research agencies leads to the conclusion that relatively greater progress has been made by the regulatory and extension groups. Research has not been idle but in many cases progress has been more lateral than forward. There have been some notable exceptions to this pattern and these are the guide posts along the path which research must take. In practically every one of the opening remarks of past presidents there has been some mention of the need for basic investigations of the numerous weed control problems but the response, in terms of reported results, has been very limited. Thus, the conference appears to be fully aware of a problem but is making only slow progress toward a solution. The reasons for this condition are numerous but two or three of them are of primary importance.

The ever present demand for practical applications is the thief of time and energy from every research worker in the area. This in turn is largely due to the scarcity of properly trained extension workers. The condition is aggravated by the normal competitive process of industrial sales effort. In most areas, farmer sales are limited by recommendations of local agricultural authorities who rely upon data supplied by research personnel.

Research on basic problems usually is slow and may be costly. Obviously adequate financial support must be available before such a project can be started. In the past 11 years financial support for short term problems that were likely to lead to immediate practical application has been readily available. Administrators frequently have not looked with favor upon the idea of a research project which proposed to study the mode of entry of any chemical. As a result we have a situation in which we suggest the application of a naphtha to control weeds in carrots, except in fields where ragweed is the most prevalent species. In this case, we suggest the use of a crop in which 2,4,-D can be used. Here, then is a fundamental problem which we choose to ignore rather than try to solve. There are similar situations in other crop and weed areas.

A comparison of the research committee recommendations released at the annual meetings in the last three years shows that, in a majority of the crops, no really significant changes have been made. The only exceptions are when one or two new chemicals have been added to the list. Thus, it appears that we already have sufficient information to enable us to raise the number of sprayed acres from one in each 10 up to two, or even four out of 10. Such an increase is not out of proportion to the need, nor would it work any hardship upon our chemical and equipment industries. The chief problem is the extension of our present know-how to more farmers or other users and will not require intensive research.

With this in mind, is it not time for our research groups to re-examine their various programs and make considerable effort to revise them toward the fundamental aspects of weed control? The problems are numerous and will be rewarding to those who undertake them. Cooperation from colleagues with needed special abilities is nearly always available and should be utilized. The necessary financial support is not so immediately available but when a start is made, generally it will be possible to secure the needed assistance. In any case, we cannot afford to wait much longer before starting the fundamental work which logically goes before practical application. In this way we should be able to show, at the end of the next 10 years, a list of

XUM

problems needing immediate attention which will not consist of 80 per cent of those we now face.

In conclusion, I should like to express the hope of the program committee that this 12th meeting may be as successful as all of the past meetings, and to thank all who have had a part in preparing for the meeting and those who are presenting the results of their work. The cooperative spirit that exists in this conference is not excelled by that of any other group known to me and I am sure that a continuation of our efforts will lead to more and better weed control.

1 President NCWCC. Michigan State University, East Lansing, Michigan.

THE SURFACE WAX OF LEAVES

R. H. Schieferstein and W. E. Loomis[1]

The interest in leaf surfaces and surface wax is due primarily to their wetability by and penetrability by foliage sprays. This study has utilized a two-stage, positive surface-replica technique for an electron-microscopic study of plant surfaces. The development of wax deposits on the primary leaf of young corn plants grown in different environments was studied in detail. The embryonic leaf, taken from the coleoptile when about ¾ inch long, had no detectable wax and an undeveloped cuticle, as evident in the textured appearance. The first material to appear on the surface, just as the leaf broke through at the tip of the coleoptile, did not appear solid but may have been either a liquid or a soft paste. Crystalline wax was apparent by the time the leaf was unrolled but still expanding. The amount of wax on the surface apparently increased until the leaf was fully expanded, but the appearance did not change after this time. Differences in wax formation due to differing temperatures, light conditions, and humidities were not striking with these young seedlings.

With fully grown corn plants it was found that only the bottom 5 or 6 leaves and possibly the top 2 leaves of plants with 14 leaves had detectable wax deposits. This did not appear to be a response to environment.

Regeneration of wax was demonstrated on young cabbage leaves from which most of the wax had been removed by wiping with dry cotton. Wax solvents killed the leaf and could not be used. As with wax development on corn leaf, the first material to appear on these wiped surfaces was not crystalline. Solid wax was apparent 4 days after dewaxing. The amount of redeposited wax increased until about 14 days after wiping, after which no further change was detected. The total of this wax was somewhat less than that orginally present. Older leaves that were dewaxed just as they were turning yellow showed no regeneration of wax deposits.

The pathway of wax through the cuticle to the surface remains unknown. Pores are indicated in some species but in our work they appeared as pits which did not extend through the cuticle. Similar pits have been observed in the under surface of enzymatically isolated cuticle samples, but here again they do not appear to be pores. None of these pits have been observed in extensive studies of corn leaves dewaxed by refluxing in a 2:1 xylene-chloroform solvent.

Mature leaves of a number of plant species have been studied. Closely related plants usually had similar surface patterns, but at times the pattern was very different, even between species of the same genus. Most grasses studied had a wax pattern similar to that of corn. This was true of *Setaria faberii* and *S. viridis*, but *Setaria lutescens* had a different and heavier type of wax structure. *Panicum capillare* was the only grass studied that showed no surface wax. The legumes as a group showed a characteristic wax pattern. For reasons unknown, *Polygonum aviculare* had a wax pattern similar to legumes. This was the only one of the several members of the *Polygonaceae* studied that showed surface wax. The surface patterns found on different species were widely varied. It is suggested that the wax pattern depends upon the cuticle, the pathway of wax through the cuticle, and the chemical constituents of the wax.

Species on which surface wax has or has not been observed are listed below:

Wax-bearing
Zea mays
Setaria faberii
Setaria viridis
Setaria lutescens
Digitaria sanguinalis
Saccharum officinarium
Amaryllis vittata
Brassica oleracea
Nicotiana glauca
Glycine max
Trifolium repens
Trifolium pratense
Melilotus alba
Pisum sativum
Lathyrus odoratus
Polygonum aviculare
Berberis thunbergii
Lonicera sp.
Musa sp.
Rosa carolina
Kalanchoe pinnata
Kalanchoe marmorata
Tropaeolum sp.
Aloe sp.
Agave sp.
Picea pungens
Mesembryanthemum lingua
Peperomia sp.

Non wax-bearing
Panicum capillare
Solanum rostratum
Solanum nigrum
Solanum tuberosum
Lycopersicum esculentum
Petunia violacea
Nicotiana tabacum
Gossypium hirsutum
Ambrosia trifida
Ambrosia artemisiifolia
Polygonum persicaria
Xanthium italicum
Ipomoea purpurea
Convolvulus arvensis
Cirsium arvense
Cirsium vulgare
Plantago lanceolata
Plantago major
Asplenium nidus
Mesembryanthemum cordifolium

The spacing of wax deposits remained constant with considerable leaf expansion. Our study indicated that the cuticle may enlarge only at the edges of the individual epidermal cells where the cuticle appeared unhardened and solid wax was not detectable. Such bands would be maintained as long as epidermal cell enlargement was sufficiently rapid. These bands are not apparent on fully grown leaves. Further study is now in progress to examine these possibly unhardened portions of the cuticle of growing leaves.

1 Iowa Agricultural Experiment Station, Ames, Iowa.

THE INFLUENCE OF STAGE OF GROWTH ON THE CONTROL OF QUACKGRASS WITH MALEIC HYDRAZIDE

W. H. Zick and K. P. Buchholtz[1]

(Abstract)

The effects of four rates of maleic hydrazide (MH), when applied at three stages of growth, upon the activity of quackgrass rhizome buds was studied. Applications of 0, 2, 4, and 8 lb. MH/A. were made in triplicate to quackgrass foliage on April 17, May 1, and May 22, 1954. At approximate intervals of 3, 6, 9, 12, and 18 days following each application rhizomes were obtained from all plots, and two 30 gram samples from each plot were planted in clay pots and set at soil depth in a fallowed area. The numbers of emerged shoots in each pot were counted six weeks and again four months after each respective sampling. Immediately after each respective four-month shoot count the new root and rhizome tissue in each pot was harvested and dry weights of each were obtained.

The ability of rhizome buds from check plots to pro-

duce emerged shoots and new root growth decreased sharply during May and early June. On the other hand, their ability to produce new rhizomes increased sharply during the same period.

The 8 lb./A. rate of MH applied on April 17, 1954, gave a slight inhibition of buds which was maintained throughout the 18-day sampling period. The 2 and 4 lb./A. rates applied at this date showed little effect at the early samplings but gave stimulation of buds at the later samplings. The 8 lb./A. rate of MH applied on May 1, 1954, gave nearly complete inhibition of emerged shoot and root production through the 6-day sampling date, and then a slow recovery was evident. The 4 lb./A. rate applied at this date gave inhibition which was not quite as complete as that of the 8 lb./A. rate. This inhibition held through the 6-day sampling, but the later samplings showed recovery and a stimulation effect. The 2 lb./A. rate at this date gave a marked stimulation of shoot and root production up to the 12-day sampling, but by the 18-day sampling this effect was overcome. All the rates of MH gave a slight inhibition of new rhizome growth at the 3-day sampling, and the 4 and 8 lb./A. rates maintained this inhibition through the 6-day sampling. After the 6-day sampling all rates of MH gave a definite stimulation of new rhizome production.

None of the rates of MH applied on May 22, 1954, gave a reduction in shoot production relative to check. On the other hand, the 2 and 4 lb./A. rates gave a marked stimulation at the first two samplings. The root growth responses at this date were similar for all the rates. All rates gave some stimulation of new root growth at the 7-day and 11-day samplings and a definite inhibition at the 16-day and 19-day samplings. The 8 lb./A. rate at this date gave inhibition of new rhizomes only at the 3-day sampling. By the 7-day sampling a stimulation was shown. The 2 and 4 lb./A. rates gave a definite stimulation of new rhizome growth at both the 3-day and 7-day samplings. Results from later samplings were not different from check.

Under the low nitrogen levels of this experiment, any inhibitions resulting from the MH applications reached their maximum from three to six days following the application of the MH and then a recovery was shown.

By far the greatest response to the MH was obtained from the May 1, 1954, applications. It appears that under normal spring conditions the period in which MH can be utilized effectively is fairly short. The limitation on the earliness of the application probably is the time when sufficient foliage is present to give an effective interception and absorption of the MH. The limitation on the lateness of application is probably the time of the occurrence of a physiological change within the quackgrass plant which reduces the effectiveness of a given unit of MH.

[1] Res. Asst., and Prof. of Agronomy, Univ. of Wisconsin, respectively. Supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

PLANT COMPETITION STUDIES WITH FIELD CORN AND *SETARIA SPP.*

By David W. Staniforth[1]

Infestations of annual grass weeds such as foxtail which survive the cultural operations associated with corn production are often relatively small. Corn yield losses which may result depend largely on the extent to which corn and weeds compete for moisture, nutrients and light. In these experiments the effects of mixed foxtail infestations on the yields of corn were investigated. Weed infestations were varied as to size and length of time they competed with corn. Conditions of corn production were varied as to level of nitrogen fertilization and corn plant populations. An area infested with yellow foxtail (*Setaria lutescens*) and green foxtail (*Setaria viridis*) was planted with a single cross corn hybrid at rates of 12,000 and 16,000 plants per acre, in 40 inch hills. Optimum amounts of P and K fertilizers were applied to the area prior to planting. Nitrogen fertilizer at rates of 0, 70 and 140 pounds per acre of elemental nitrogen was applied shortly after planting. All plots were cultivated to remove weeds from between hills and to leave moderate to heavy foxtail infestations in the hills of corn. These infestations were then removed at each of five stages of corn growth, and the plots kept weed-free for the rest of the season. Stages of weed removal were: at corn emergence, corn with 8-10 leaves emerged, two weeks before tasselling, at tassel emergence, and at corn maturity. Yields of weeds at each date of removal and yields of corn at maturity were obtained. The experiments were conducted in 1954 and 1955 on the same area of land.

Experimental Results

In 1954 rainfall was heavy, weed infestations averaged 500 pounds per acre of dry matter at maturity, and corn yield reductions from such infestations were relatively small. Yield reductions of 6 to 8 bushels per acre of corn resulted when weeds were left to maturity in plots which received no nitrogen fertilizer and in plots which received 70 pounds per acre of nitrogen with 16,000 corn plants per acre. No appreciable corn yield losses from weed infestations resulted with nitrogen applications of 140 pounds per acre, even when weeds were left to maturity. When weeds were removed from the corn at or prior to tassel emergence no yield reductions resulted. Yields of weeds were slightly lower in plots with 16,000 corn plants per acre than with 12,000 plants per acre. Lower yields of weeds were associated with low nitrogen fertilizer applications.

Total rainfall in the 1955 growing season was about half that received in 1954, but yields of corn in fertilized, weed-free plots were equal to those obtained in 1954. Weed infestations were about 50 per cent heavier in 1955, averaging 600 to 900 pounds dry matter per acre. The corn yield reductions which resulted from these infestations were much greater than in 1954, and were large in many instances even when the weeds were removed early in July. The pattern of losses, however, was similar to that of 1954, with respect to the effects of nitrogen level on losses from weeds. Significant yield losses occurred with weeds left in competition with corn to maturity in all plots. Losses were greatest in plots low in nitrogen fertilizer and least in plots heavily fertilized with nitrogen. In both seasons high levels of nitrogen fertilizer produced the highest yields of both corn and weeds, and the lowest yield losses due to weed infestations.

[1] Iowa State College, Ames, Iowa

THE DISTRIBUTION OF RADIOACTIVE AMINO TRIAZOLE IN PLANTS

B. J. Rogers[1]

Amino triazole, or more properly, 3-amino-1,2,4-triazole, has the unusual property of inhibiting the synthesis of chlorophyll in many plants. Although little evidence exists which points to an inhibition of synthesis rather than a degradative process, it seems safe to assume the former alternative because in most treated plants it is the newly-forming plant parts which are found to be deficient in chlorophyll, and not those in which chlorophyll is already present.

Investigations aimed at elucidating the point of inhibition are now in a preliminary stage. Through the

XUM

generosity of the American Chemical Paint Co., we have been supplied with a quantity of C^{14}-labeled amino triazole. The C-5 atom in the ring is labeled. With this radioactive material we have been able to follow, through the use of radioautographs, the movement of amino triazole trough plants of Canada thistle, Johnsongrass, wild garlic, and soybean. In these plants, the chemical is translocated quite generally throughout the younger parts of each plant, from growing point to roots. The older leaves—actually those not metabolizing rapidly—apparently pick up very little of the chemical.

Dried leaves from soybean plants treated with radioactive amino triazole were ground in a mortar. The powder was extracted with acetone and then with water. The residue consisted essentially of cell-wall material. The water extract was boiled for 10 minutes and the protein precipitated by this treatment was collected by centrifugation. The protein was washed several times in water, then several times in cold and hot 3% TCA solution, and then again in cold 3% TCA. The specific radioactivity found after each of this series of washings is recorded in Table I. At the third washing in TCA the amount of protein decreased by some 30%. It seems likely that hydrolysis of the protein occurred, and at the same time the radioactivity was markedly decreased. It is not possible at the present time to state unequivocally that a protein-amino triazole complex was formed.

The supernatant water solution and the acetone extract were evaporated to dryness, plated on counting planchets, and the specific radioactivity determined. The cell-wall material was washed twice in water—the specific activity was measured after each washing. These data are included in Table I.

Table I.

	Spec. Act., cpm/mg.
Acetone extract	3,640
Water extract	135,000
Cell-wall material:	
1st washing	10,650
2nd washing	6,240
Protein:	
1st washing—water	6,580
2nd washing—3% TCA	6,000
3rd washing—3% TCA	910

Small aliquots of the water extract and the acetone extract were chromatographed on paper and the distribution of radioactivity was studied after development of the chromatogram with a phenol: water solvent (Table II.)

Table II.

Zone on Paper		Water Ext.	Acetone Ext. cpm	Amino Triazole
Origin	0	36	0	0
	1	60	0	0
	2	33	0	0
	3	34	0	0
	4	32	0	0
	5	67	0	0
	6	188	0	0
	7	272	0	0
	8	243	0	0
	9	196	2	6
	10	78	7	8
	11	59	9	9
	12	37	19	36
	13	31	16	318
	14	22	10	756
	15	9	13	119
	16	7	7	6
	17	7	0	2
	18	3	1	0
Front	19	0	5	0

As may be seen in the table, the peaks from amino triazole and the acetone extract coincide. The peak for the water extract evidently has nothing in common with the other two. There seems to be a good possibility that the amino triazole has been converted to some other compound in the plant. This lead toward an explanation for the action of amino triazole is to be pursued in the near future.

[1] Dept. of Botany and Plant Pathology, Purdue University, Lafayette, Indiana

THE EFFECT OF 2,4-D AND TIBA ON AN AUXIN TRANSPORT MECHANISM IN BEAN STEMS

Hay, James R.[1]

In the course of studies on the translocation of 2,4-D in plants it appeared that at high concentrations 2,4-D interfered with the mechanism responsible for its own movement (1). Kuse has presented evidence to show that 2,3,5-triiodobenzoic acid (TIBA) probably has an inhibiting effect on the transport mechanism of natural auxins (2).

In the present work, direct measurements were made of the effects these compounds have on the auxin transported through 5 mm sections of stems of 9 day old bean seedlings. Donor agar blocks containing indoleacetic acid (IAA) were placed on the apical end and blank receiver blocks were at the basal end. The amount of auxin transported to the basal blocks was then measured by the Avena test. The effect of 2,4-D and TIBA on the mechanism responsible for transport in these excised sections was studied by (1) pre-treating the stem sections with these compounds and (2) by pre-treating the seedlings from which the sections were removed.

Preliminary studies were made to show that 2,4-D and TIBA were not interfering with the test plants used in the bioassay.

The sections were pre-treated by placing agar blocks containing 0, 10, 100 mg/1 2,4-D on the apical end. After 4 hours, these blocks were replaced with blank blocks and the pre-treatment continued for 3 more hours. The stem sections were then transferred to blank receiver blocks and donor blocks containing 0 and 10 mg/1 IAA were placed on top. The amount of IAA transported in 2 hours was then measured.

Table 1 shows that pre-treatment with 2,4-D at 10 mg/1 caused a slight reduction in transport as indicated by the curvatures produced by the receiver blocks. Following pre-treatment with 100 mg/1 2,4-D there was a very marked inhibition in the amount transported.

In the second series of tests, the transport of IAA was measured in sections of stems taken from bean seedlings which had previously received a foliage application of 2,4-D or TIBA. Fifty micrograms were applied to the primary leaf of the seedlings in the light and, at 24 hours, 5 mm sections were removed from the stem and petiole. They were set on moist filter paper for two hours to allow any auxin already present to be transported out. Donor blocks of 0 and 10 mg/1 IAA were then placed at the apical end. Table 2 shows that quite substantial amounts were transported through the epicotyl and petiole sections of untreated plants but much lower amounts moved through sections taken from seedlings which had been previously treated with 2,4-D or TIBA.

It seems clear, therefore, that the mechanism, which is responsible for the transport of IAA through excised sections of bean stems, is disrupted when 2,4-D or TIBA are applied to the foliage. It is not known whether or not this is the mechanism by which 2,4-D moves when applied as a herbicide. However, if this mechanism

XUM

operates in intact plants it is probable that when these compounds are applied to leaves or stems, they interfere with transport of IAA at least.

Table I.

Transport of IAA in 2 hours through 5 mm sections of bean hypocotyls pre-treated with 2,4-D

Pre-treatment	Transport of	Curvature
Blank	IAA 10 mg/l	21
2,4-D 10 mg/l	Blank	1
2,4-D 10 mg/l	IAA 10 mg/l	15
2,4-D 100 mg/l	Blank	7
2,4-D 100 mg/l	IAA 10 mg/l	7

Table II.

Transport of IAA through sections taken from bean seedlings, the primary leaf of which had been treated with 50 mg of 2,4-D or TIBA 24 hours before.

	Curvature produced by receiver blocks	
	Epicotyl	Petiole
No treatment	31	31
Pre-treated with 2,4-D	7	14
Pre-treated with TIBA	2	—

Literature Cited

1) Hay, J. R. and Thimann, K. V. The fate of 2,4-D in bean seedlings. II. Translocation. Plant Physiol. (in press).

2) Kuse, G. Effect of 2,3,5-triiodobenzoic acid on the growth of lateral buds and tropism of petiole. Memoirs Coll. of Sc. Univ. of Kyoto B. xx 207-215. 1953.

1 Field Husbandry Division, Central Experimental Farm, Ottawa.

THE TRANSLOCATION OF HERBICIDES

G. E. Barrier and W. E. Loomis[1]

The translocation of organic solutes in plants has long puzzled men who worked with the process, and the use of chemical herbicides has renewed interest in the subject. It has been shown that 2,4-D moves out of treated foliage through the phloem. The temperature and the presence of carbohydrate have been shown to affect the rate of 2,4-D translocation, but the mechanism involved has not been established.

The purposes of this work were to study the translocation of 2,4-D and to compare the behavior of 2,4-D and P^{32}. Since P^{32} can be detected in a plant with much greater accuracy than 2,4-D, it was used as a "pseudo-herbicide" that could be traced throughout the plant.

Treatments were applied to one unifoliate leaf of soybean plants while the trifoliates were still rolled in the bud. The treated leaves were left on the plant under controlled conditions to permit translocation from them. They were then removed and translocation measured by observations on the remainder of the plant. The green weight of the new growth was used as an inverse measure of 2,4-D in the plant, and P^{32} in various tissues was measured by pressing the dried material into briquets and counting them with a Geiger tube.

Since little was known concerning the absorption of P^{32}, this work was necessary before translocation studies could be performed. While the addition of a wetting agent may increase the absorption of 2,4-D by 800 to 1000%, wetting agents were of little value in increasing the absorption of P^{32}. Three wetting agents reduced the absorption of P^{32}, presumably because of reactions with the phosphorus. These differences between wetting agents were only apparent when 20 ul of solution were used. There was probably not enough wetting agent in 10 ul of solution to tie up the P^{32}.

Increasing the temperature 10° C (18° F) doubled the rate of absorption of 2,4-D but had no effect on the rate of absorption of P^{32}.

It is assumed that these effects are due to differences between the absorption of an undissociated organic molecule and an inorganic ion, and represent differences in the mechanisms involved.

Increasing the temperature 10° C approximately doubled the rate of translocation of both 2,4-D and P^{32} from treated leaves. In these experiments two hours were allowed for the absorption of the treatment, then the treated leaf was washed to remove any unabsorbed material from the surface. After 24 hours of exposure at the desired temperature the treated leaf and petiole were removed. Translocation was then measured in reduced growth with 2,4-D or by counting P^{32}. This response to temperature is characteristic of chemical reactions and indicates that the rate of translocation is limited by a biochemical mechanism.

The presence of carbohydrates in the leaf was necessary for the translocation of both 2,4-D and P^{32}. When sucrose was supplied above, or with the application of 2,4-D or P^{32} to plants that had been in the dark for 24 hours, translocation was increased. When the plants were in the light after treatment, the application of sucrose slightly increased the amount of 2,4-D translocated. If the sucrose was applied below the point of application of P^{32} the movement of phosphorus out of the leaf was not increased. These results indicate that the sucrose moved downward in the leaf from the point of application and so did not come in contact with P^{32} applied above it.

It has been reported that 2,4-D was translocated from carbohydrate depleted kidney beans when applied in 0.05 ml of kerosene. When 0.05 ml of a non-phytotoxic Number 10 Base oil was used as a carrier for 2,4-D, the herbicide was found to move from carbohydrate depleted soybeans in a much greater quantity than when water was used as a carrier. The treatment was applied in a small aluminum ring sealed to the leaf with agar and the leaf removed after 24 hours in the dark. When a toxic oil, Lion 6, was applied, the plants were killed without the addition of 2,4-D. The indications were that the oil creeps through the plant tissues carrying the 2,4-D with it.

A solution of P^{32} and X-100 was spread uniformly over the surface of excised beet leaves and the leaves thoroughly washed to remove the residue after an absorption period. Radioautograph of the leaves showed that the P^{32} had been largely concentrated in the veins. Energy must have been used to collect and hold this phosphorus against a concentration gradient. It appears that the P^{32} is being "pumped" into the veins, even though appreciable translocation was impossible in these excised leaves. These results are evidence for a "loading" operation dependent upon respiratory energy as the first step in translocation.

1 Iowa Agricultural Experiment Station, Ames, Iowa.

THE INHIBITORY ACTION OF A GARLIC EXTRACT ON STARCH SYNTHESIS IN CORN

R. D. Hart, G. A. Gries and B. J. Rogers[1]

Substances which are produced by one organism and which bring about growth inhibition or even death in another organism are found in several branches of the plant kingdom. This antibiosis came into prominence when penicillin, originally discovered in 1929 (1), came into wide use during the early 1940's. Bacterial inhibitors have also been found in higher plant forms (2).

Several reports have indicated that compounds are produced by higher plants which are toxic to other

XUM

plants. Instances have been reported of plants excreting unknown substances into the soil which affect later crops. Another example of inhibitors are unknown substances which prevent the germination of the seeds in fruits. In 1949, H. C. Eyster (3) observed in certain members of the lily and amaryllis families a principle which he found to prevent starch synthesis in etiolated corn leaves. This paper is a preliminary report on an investigation into the mechanism of the action of this principle and is to be followed at a later date by a report on attempts to characterize the compound itself.

Wild garlic (*Allium vineale*), a noxious weed in some sections of the midwest, was chosen as a source of the inhibitor. The plant material was ground to a pulp in a Waring blendor with a minimal amount of cold water. The juice was clarified by passing through several thicknesses of cheesecloth. Discs cut from the leaves of corn plants which had been maintained in the dark for 24 hours immediately prior to use were used to determine the presence of the inhibitor. Discs of the starch-free leaves were floated for 24 hours on a 0.5 M glucose solution. The pigments were removed with hot acetic acid, and then tested for starch with potassium iodide solution. Similar discs were also floated on equal amounts of glucose and various dilutions of garlic extract. The clarified solution was demonstrated by this method to contain the inhibitor.

The procedure used to concentrate the inhibitor is as follows: extraction from the clarified water filtrate with chloroform; extraction from the chloroform into one half the original volume of water by evaporation of the chloroform *in vacuo;* acidification with phosphoric acid and steam distillation. The distillation was made basic with sodium hydroxide and steam distilled. The residue was then made acidic again with phosphoric acid and the steam distillate extracted with ethyl ether. The ethyl ether fraction was evaporated to dryness at 0°C. During the course of ether evaporation, any remaining water was filtered off as ice.

The brown viscous material obtained was weighed immediately and then dissolved in chloroform. Aliquots of the chloroform solution were dissolved into water by evaporation *in vacuo*. Tests indicated that this end product would prevent starch synthesis in the test system used.

The second phase of this investigation deals with the specific step in starch formation inhibited by this material. The mechanism of action of this inhibitor was studied by use of *in vitro* systems (4).

The first step tested for inhibition was the conversion of glucose-1-phosphate to starch. A crude phosphorylase enzyme was prepared from potato. Upon the addition of glucose-1-phosphate, starch was formed in the presence of the inhibitor.

The second step tested was the formation of glucose-6-phosphate from glucose in the presence of ATP, hexokinase and magnesium ions. This step was also demonstrated to proceed in the presence of the inhibitor.

The last step, the conversion of glucose-6-phosphate to glucose-1-phosphate in the presence of phosphoglucomutase and magnesium ions was studied. A crude enzyme preparation was prepared from heart muscle. Since the equilibrium is 95% toward the glucose-6-phosphate, the reaction was studied by measuring the conversion of glucose-1-phosphate to glucose-6-phosphate. It was demonstrated by paper chromatography (5) that the presence of the inhibitor caused a marked decrease in the amount of glucose-6-phosphate formed in this reaction. It is therefore felt that this is the step which is inhibited by the extract from garlic.

The nature of this compound is being studied. There has been a compound isolated from garlic which has been shown to be an antibacterial agent (6). They determined this compound to be allyl 2-propene-1-thiosulfinate (7). The possibility that their compound is the same as the one described here is under investigation.

If natural inhibitors can be isolated and identified, it is conceivable that this might lead to the use of such inhibitors or derivatives of these inhibitors in the control of weeds.

Literature Cited

1. Flemming, A.
   An antibacterial action of cultures of penicillium with special reference to their use in the isolation of *B. influenzae*. Brit. J. Exp. Path. 10:226, 1929.
2. Audus, L. J.
   Plant growth substances. Interscience Publishers, Inc., New York, 1953.
3. Eyster, H. C.
   Inhibitor in onion for starch synthesis. Science 109:382, 1949.
4. Colowick, S. P., Sutherland, E. W.
   Polysaccharide synthesis from glucose by means of purified enzymes. J. Biol. Chem. 144:423, 1942.
5. Bandurski, R. S. and B. Axelrod.
   The chromatographic identification of some biologically important phosphate esters. J. Biol. Chem. 193:405, 1951.
6. Cavallito, C. J. and J. H. Bailey.
   Allicin, the antibacterial principle of *Allium sativun*. J. Am. Chem. Soc. 66:1950, 1944.
7. Small, L. D., J. H. Bailey and C. J. Cavallito.
   Alkyl thiosulfinates. J. Am. Chem. Soc. 69:1710, 1947.

1 Dept of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

PHYTO-TOXIC MATERIALS IN SEVERAL PERENNIAL WEEDS

E. A. Helgeson

Actually these experiments were run to determine whether or not 2,4-D increases the nitrate content of vegetative tissue of Canada thistle, field bindweed, willowleaf dock and leafy spurge.

Since our chemical determinations showed no appreciable change in nitrate content we decided to look for phyto-toxic effects.

Materials and methods: With the exception of dock, the weeds were in a fairly vigorous vegetative condition when sprayed. Dock was in the early bud stage.

Plants were sprayed to run-off with an aqueous solution of an amine formulation of 2,4-D at a rate of one-half pound per acre. Four plots each one square rod in area were treated for each weed. Sprays were applied on September 23, 1953 and vegetative samples were collected 3, 5 and 10 days after sprays were applied.

Stems and leaves were dried to constant weight at 70° C in a steam oven. The dry tissue was ground to a fairly fine powder and stored at laboratory temperature in paper bags until last summer when determinations for toxicity were made.

Extracts were prepared by leaching with distilled water for one hour at room temperature with constant shaking. Extracts were filtered and used to moisten filter paper in Petri dishes.

Dakota flax seeds were placed between such moistened papers and incubated at 20° C for 5 days. Concentrations of extract employed were 1:10 (1 gram weed residue plus 10 ml. distilled water) 1:20 and 1:30. A minimum of 200 seeds was used in each test. Root growth reported in terms of a control grown on paper moistened with distilled water is reported in the following table as well as percent germination.

XUM

Canada Thistle
Extract Concentration

Days after treatment	1:10 Cont* G**	1:10 Cont* L**	1:10 2,4-D* G	1:10 2,4-D* L	1:20 Cont G	1:20 Cont L	1:20 2,4-D G	1:20 2,4-D L	1:30 Cont G	1:30 Cont L	1:30 2,4-D G	1:30 2,4-D L
3	73	17	10	3	78	52	60	10	87	76	76	22
5	79	6	16	2	75	53	32	8	80	71	85	19
10	83	25	18	4	90	78	86	8	91	86	88	21
Leafy Spurge												
3	68	54	70	23	77	94	82	67	72	71	80	65
5	66	57	76	29	85	91	77	66	78	69	85	71
10	76	52	62	7	84	78	78	29	83	84	81	38
Bindweed												
3	70	16	18	3	84	59	54	5	82	61	84	10
5	82	31	25	3	90	49	83	12	90	93	89	23
10	89	34	40	5	86	51	83	20	89	54	87	37
Willowleaf Dock												
3	79	11	53	4	85	31	74	9	88	53	77	17
5	78	12	64	7	77	34	64	19	84	48	74	31
10	53	10	50	4	68	18	70	18	75	26	75	29

** G = % germination; L = length of roots as % of control; Cont = plant residue not treated; 2,4-D = plant residue treated with 2,4-D.

Discussion:

A study of the data indicates that the untreated material generally had little or no effect on germination, whereas there was a decided reduction in length of root produced, at least in the more concentrated extracts. Material from sprayed plants showed some reduction in percentage germination in higher concentrations in all species except spurge and all concentrations had a more or less severe growth depressing effect. There seemed to be no general correlation between the samples harvested at the several periods after treatment.

In general Canada thistle extracts were most toxic followed by bindweed, dock and spurge in diminishing order of toxicity.

Further studies are under way to determine some definite chemical and physical characteristics of the toxic materials involved in these plant residues. (Contribution from the N. D. Agric. Expt. Sta. under Purnell project #139.)

PRELIMINARY STUDIES ON THE GERMINATION OF WEED SEEDS

B. J. Rogers and F. W. Stearns[1]

Studies on weed seed germination are interesting for several reasons: (1) certain weed control measures may ultimately depend on control, in the soil, of seed germination; (2) it is highly desirable to be able to produce all types of weeds at definite times for testing herbicides; and (3) germination *per se* is a fascinating physiological problem.

A general survey is being made at this station to determine the specific problems involved in the germination of seed collected from weeds in Indiana. A test system has been set up in order to standardize the work. The seeds are germinated in petri dishes under a variety of conditions. Two petri dishes, each containing 20 seeds, are set up for each species under each condition. The seeds are placed on filter paper which in turn rests on squares of tissue paper. This double layer of paper aids in aeration and also in water-holding capacity, without being too adsorbent. The conditions are: light (250 fc., fluorescent) and dark at 23°C.; light and dark as before, but with the tissue paper resting not on the glass bottom of the dishes, but on a ⅛-inch layer of a fine grade of Norit—a commercial pinewood charcoal adsorbent; and an alternating temperature system (3°C to 23°C) in which the seeds are switched every second day. These latter seeds also alternate from dark at 30°C to light (75 fc., fluorescent) at 23°C. The total germination period varies from 21 days to 30 days.

Certain of the results (given in percent germination) obtained with this survey are as follows:

Table I

Plant	Light	Dark	Norit Light	Norit Dark	Alt. Temp.	Days
Setaria lutescens:						
Collected 1953	26	24	41	59	18	21
Collected 1955	0	0	0	0	0	30
Lychnis alba:						
Collected 1954	98	92	87	74	92	30
Collected 1955	92	92	41	49	100	30
Echinochloa crusgalli:						
Collected 1954	0	3	55	7	0	21
Collected 1955	0	4	4	0	4	28
Descurainia sophia:						
Collected 1954	0	0	0	0	65	30
Collected 1955	10	32	35	37	80	29
Lactuca scariola:						
Collected 1953	45	90	84	97	84	30
Collected 1955	63	9	97	86	60	28
Pastinaca sativa:						
Collected 1954	3	14	10	7	21	30
Collected 1955	0	0	0	0	75	30
Arctium minus:						
Collected 1954	79	29	59	35	100	30
Collected 1955	12	0	—	24	100	28
Ipomea hederacea:						
Collected 1953	87	90	77	82	90	30
Collected 1955	48	15	70	100	18	28
Daucus carota:						
Collected 1953	28	36	36	50	47	21
Collected 1955	42	8	35	12	75	28
Datura stramonium:						
Collected 1953	100	87	47	60	95	29
Collected 1954	55	8	5	0	90	29
Collected 1955	46	3	3	10	28	28

In general, old seed gives the best germination with one exception—*Descurainia sophia.* Most of the seeds germinate well under conditions of alternating temperature. The reason for this is rather difficult to see, unless it is a matter of an impermeable seed coat which gradually weakens under stresses brought about by sudden changes in temperature. The results (percent germination) of investigations into the effect of seed coats on some recalcitrant seeds are shown below:

Table II

Plant	Light	Dark	Alt. Temp.	Days
Polygonum pennsylvanicum:				
Fruit coat intact				
Collected 1953	0	0	60	21
Collected 1955	0	0	0	26
Fruit coat removed				
Collected 1953	40	20	40	18
Collected 1955	35	45	45	14
P. convolvulus:				
Fruit coat removed				
Collected 1955	80	—	—	6
P. persicaria:				
Fruit coat removed				
Collected 1955	100	—	—	6
Solanum carolinense:				
Seed coat intact				
Collected 1954	0	2	5	30
Collected 1955	0	0	0	28
Seed coat removed				
Collected 1955	50	25	40	3

Germination of the *Polygonum* spp. seems to be largely a matter of a seed coat which in some manner restricts germination. The young seedings appeared normal in every respect. *Solanum carolinense,* on the other hand, appears to suffer from a type of seedling dormancy, rather than seed dormancy. The hypocotyls emerge readily, but at that point growth ceases. This phenomenon has been observed in other plants. Further study on this particular type of seedling dormancy is anticipated.

[1] Dept. of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

THE INFLUENCE OF LIGHT AND TEMPERATURE ON GERMINATION AND FLOWERING OF FIVE SPECIES OF PLANTAGO

Forest Stearns[1]

In the life cycle of all plants there are certain critical phases which require environmental tolerances narrower than those permissible for successful vegetative growth. Seed germination, seedling development, floral initiation and pollination may each require a specific combination of conditions the absence of which will result in failure to set seed or failure to become established on a given site. The composition and perpetuation of field, garden or lawn weed communities for example depends upon a galaxy of factors operating simultaneously upon many different plant species.

The work reported here is a small part of that which will be necessary to delimit the critical periods in the life cycles of *Plantago* species. When these critical periods are defined it will be possible to relate specific environmental conditions to the observed ecological behavior of a species.

Data presented in Table I indicate that the five species studied have a wide variation in germination requirements in respect to both temperature and light conditions.

Several species show a pronounced increase in germination at an 8 hour day over that obtained at a 16 hour day when grown at 80° F. Similar responses have been demonstrated for *P. lanceolata* in other experiments. *P. Rugelii* and *P. major* which closely resemble each other in appearance, although apparently distinct species, show similar germination behavior in respect to the variables studied. These perennial species, *P. Rugelii* and *P. major*, germinate most successfully at 80° F. while the annual species, *P. aristata*, germinates far more readily at 60° F. Germination experiments with activated carbon suggest that *P. Rugelii* seed may contain an inhibitor removable by charcoal while the other four species do not. The absence of light seems to decrease germination in all species at 80° F. but has little influence at 60° F.

Table I

Per cent germination of five species of *Plantago* at 60° F. and 80° F. in 8 and 16 hour photoperiods and in complete darkness.

		% Germination			
Species		*P. virginica*	*P. lanceolata*	*P. lanceolata*	*P. aristata*
Seed Year		1955	1953	1955	1955
80° F.	16 hr.	92	28	4	4
	8 hr.	100	68	24	80
	Dark	16	14	18	0
60° F.	16 hr.	100	44	28	100
	8 hr.	100	56	44	100
	Dark	92	46	46	88

Species		*P. Rugelii*		*P. major*	
Seed Year		1955	1955	1954	1955
80° F.	16 hr.	28	0	20	60
	8 hr.	64	0	60	100
	Dark	26	0	2	16
60° F.	16 hr.	0	0	36	0
	8 hr.	0	0	20	0
	Dark	0	0	4	0

The conditions necessary for the initiation of flowers also vary within the genus. Results of an experiment conducted in the Purdue Controlled Weather Chambers are summarized in Table II.

As one would expect, higher temperatures tend to hasten flowering. However, the delay in flowering of *P. lanceolata* at 80° F. over the time required at 70° F. is marked and has been demonstrated in several experiments. None of three species produced flowers when grown at an 8 hour photoperiod and only *P. aristata* flowered in a 12 hour day. Neither *P. Rugelli* nor *P. lanceolata* showed any indication of floral initiation at the time it became necessary to remove them from the control chambers.

Table II

Days from germination to flowering.

	P. aristata	*P. Rugelii*		*P. lanceolata*
			Greater than	
60° F.				
12 hr.	200	0	250	0
16 hr.	91	116		130
70° F.				
12 hr.	145	0	180	0
16 hr.	74	56		51
80° F.				
12 hr.	117	0	160	0
16 hr.	50	49		59

In addition to the work reported other investigations are in progress and prospect on *Plantago* species both in the laboratory and the field. It is hoped that the complete life histories of these plants will eventually be elucidated.

[1] Department of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

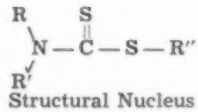
THIO-ESTERS OF N-SUBSTITUTED DITHIOCARBAMIC ACID AS SELECTIVE HERBICIDES

Philip C. Hamm, John J. D'Amico, and Marion W. Harman[1]

A SUMMARY

The alkyl, alkenyl and halo-alkenyl esters of N-substituted dithiocarbamic acid are outstanding pre-emergence herbicides for the control of germinating seeds and most specifically for grass seeds. The activity per unit of chemical is comparable to that of the N-substituted α-chloroacetamides.

The basic nucleus is readily modified on either end, i.e. S-ester or N-substituents creating a multitude of structural changes. Hundreds of these modifications were made and tested during the course of this investigation. An appreciable insight into the correlation of structure, herbicidal activity and plant specificity was achieved by means of an empirical herbicide screening program.



Structural Nucleus

Method of Testing

The results discussed here are based on pre-emergence greenhouse screening studies. Many of those compounds indicated as inactive pre-emergence chemicals are active as contact spray herbicides. Our screening evaluation method is the same as outlined in a previous paper on α-chloroacetamides.*

* North Central Weed Control Conference 1954

Nature of these Compounds

Physically the compounds range from liquids to solids with most of the more active derivatives being liquids. Practical field formulations are most easily formed via the emulsion route, i.e. four pound per gallon concentrates prepared with solvent and emulsifier ready for dilution with water. Toxicology tests indicate a relatively low order of acute toxicity to rats. The reported LD_{50} for one of the most active derivatives is 850 mg/kgm. The greatest action from these chemicals

is observed on germinating seeds and is more evident on grass seeds than on seeds of broadleaf plants.

Complete germination inhibition of seeds of wild oats, cheat grass, rye grass and giant foxtail has been achieved in greenhouse tests at rates of 1 to 2½ lbs. per acre with little or no injury evident on cotton, sugarbeets, red clover, cucumber, soybeans and corn. At higher rates progressively more broadleaf plant species succumb to these chemicals. Certain broadleaf plant species remain almost uninjured at rates as high as 25 lbs. per acre.

The following table provides a more precise idea of the relative resistance or susceptibility of seeds of a number of plant families to 2-chloroallyl diisopropyldithiocarbamate.

Per Cent Germination Inhibition by 2-Chloroallyl Diisopropyldithiocarbamate on Several Plant Species at 2 Application Rates

Seeds	per acre 25 lbs.	per acre 2½ lbs.
Corn	25	0
Wild oats	100	100
Cheat grass	100	100
Rye grass	100	100
Giant foxtail	100	100
Buckwheat	50	25
Radish	25	0
Red clover	75	25
Sugar beets	50	0
Cotton	50	0
Cucumber	100	25

Results

1. The smallest structural difference may change the specificity and the total toxicity from complete inactivity to outstanding activity.
2. Three-carbon S-esters or 3-carbon di-N-substituents produce maximum heights of activity.
3. Nitrogen substituents other than hydrogen are required for any degree of pre-emergence activity.
4. Both hydrogens attached to the nitrogen atom must be replaced with alkyl radicals to obtain pre-emergence activity
5. Unsymmetrical aliphatic N-substituents produce very active herbicides.
6. The introduction of a hydroxy thio ester results in inactivity.
7. The 4-carbon entity, either butyl or butenyl derivatives, result in reduced toxicity to brome grasses.
8. The trichlorobenzyl S-ester combines both broadleaf and grass action.

[1] Monsanto Chemical Company, Organic Chemicals Division Research Department, St. Louis 4, Missouri, and Nitro, West Virginia.

THE EFFECT OF POTASSIUM N-1-NAPHTHYLPHTHALAMATE ON THE GEOTROPIC RESPONSE AND GROWTH OF CORN, PEA AND OAT SEEDLINGS[1]

Ching, Te May Tsou, Robert H. Hamilton*, Robert S. Bandurski, Buford H. Grigsby and G. B. Wilson[2]

Previous studies from this laboratory (1) and by Netien (3, 4) have indicated an inhibition of the geotropic response of pea, vetch, composite and crucifer seedlings by N-1-naphthylphthalamic acid (NP). These observations are of interest because the classical theory of the mechanism of the geotropic response (5) requires a direct correlation between growth and geotropic curvature. Thus curvature can only result from unequal growth on two sides of a growing organ and inhibition of growth should always result in proportional inhibition of curvature. Quantitative studies were conducted to determine if the inhibition of the geotropic response by NP was due solely to inhibition of growth or to a selective effect of NP on the tropic movement.

Commercial NP was recrystallized from acetone petroleum ether (M.P. = 191°C.) followed by conversion to the potassium salt. All seedlings were germinated at 25°C in the dark. *Avena* coleoptiles were grown by standard *Avena* test procedures (2) and used when 2.0 - 2.5 cm long. Single cross hybrid corn (W23 x oh51A courtesy of Dr. E. Rossman) and Alaska peas were germinated in rolls of moist paper towelling. Corn and pea roots from 2.0 - 2.5 cm in length, and shoots from 1.0 - 1.5 cm in length were used. *Avena* seedlings were soaked for 30 minutes in NP solutions buffered at pH 4.5. Pea and corn seedlings were soaked for 1 hour in NP or 2,4-dichlorophenoxyisobutyric acid (2,4-DIBA).

Following treatment, seedlings for straight growth test were marked 6mm. from the tip, and then placed in the normal upright position. For geotropic response test, seedlings were mounted in horizontal position. Both sets of seedlings then were incubated in moist darkness at 25°C.

It was found that growth of corn roots was linear during a 4 hour test period (Table I). Curvature was approximately a linear function of time from 40 minutes to 2 hours. After 2 hours there was a decrease in rate of curvature and curvature was essentially complete at the end of 4 hours. Growth and geotropic curvature, at the end of a 4 hour incubation period, were determined for untreated controls and plants treated with various concentrations of NP and 2,4-DIBA. Growth and curvature for treated plants were expressed as percent of that of the untreated control, and plotted against concentration of NP or 2,4-DIBA. The concentration required for 50% inhibition as estimated graphically is summarized in Table II.

Table I
Time Course of Straight Growth in mm. and Geotropic Curvature in Degrees of Corn Roots

Straight growth (mm)			
Hrs.	Mean	S.E.	No. of Plants
1	.99	±.048	47
2	1.78	±.075	46
3	3.21	±.081	49
4	4.35	±.146	47
Geotropic curvature (°)			
Time (Min)	Mean	S.E.	No. of Plants
45	7.86	±1.68	29
80	31.89	±2.09	29
120	40.48	±2.16	29
180	54.79	±2.96	29
240	48.76	±1.50	29
360	46.31	±1.78	29
480	50.31	±1.71	29

Table II
Concentrations required for half inhibition of straight growth and geotropic curvature after 4 hours incubation.

Material	Chemical	Growth	Curvature
Corn roots	DCIB	1×10^{-4}M	2×10^{-4}M
Corn roots	Alanap	$> 10^{-3}$M	5×10^{-5}M
Avena coleoptile	Alanap	10^{-4}M	5×10^{-5}M
Corn shoots*	Alanap	$> 10^{-3}$M	7×10^{-5}M
Pea roots*	Alanap	5×10^{-4}M	7.5×10^{-6}M
Pea shoots*	Alanap	10^{-3}M	5×10^{-5}M

* Only two experiments.

As can be seen from the data of Table II, the concentration of NP required for 50% inhibition of growth is not always equal to the concentration required for 50% inhibition of geotropic curvature. For example, in corn roots, 5×10^{-5} M NP resulted in a 50% inhibition

XUM

of geotropic curvature and only a negligible inhibition of straight growth. A concentration of greater than 10^{-3}M was required for 50% inhibition of straight growth. This selective inhibition of the geotropic curvature as compared to growth was also noted for corn shoots and pea roots and shoots. *Avena* coleoptile growth and curvature inhibition were roughly proportional. A known auxin antagonist, 2,4-DIBA was found to give proportional inhibition of growth and the geotropic response of corn roots. Additional experiments were performed to determine if NP was an anti-auxin (2). The results indicated a non-competitive relationship at low indoleacetic acid (IAA) levels, but some competitive action at high IAA levels.

Summary:

It is apparent that NP can abolish the geotropic sensitivity of corn and pea seedlings without greatly reducing straight growth. The action of NP is probably not a direct result of competition between NP and IAA since 2,4-DIBA does not give a similar action. Also, the interaction between IAA and NP in growth of *Avena* coleoptiles sections is not a simple competitive one. The classical theory of auxin mediated geotropic bending involves a mechanism of lateral redistribution of auxin. Our present results are difficult to account for the terms of the classical theory. The possibility that NP interferes with lateral auxin transport in plant tissue has however not been excluded.

Literature Cited

1. Grigsby, B. H., Te May Tsou, and G. B. Wilson. Some effects of Alanap (NP) and Amizole on germinating peas. Proc. 11th North Central Weed Control Conf. 88-90. 1954.
2. McRae, D. H., R. J. Foster, and J. Bonner. Kinetics of auxin interaction. Plant Physiol. 28:343. 1953.
3. Mentzer, Co. et G. Netien. Sur un procede permettant de troubler le geotropisme des racines. Bull. Mens. Soc. Linneenne. Lyon, 19: 102-104. 1950.
4. Netien, G., and R. Conillot. Action de l'acide 2 naphthyl-phthalamique sur la germination et les premiers stades de crossance des vegetaux. Bull. Mens. Soc. Linneenne. Lyon, 20:49-52. 1951.
5. Went, F. W., and K. V. Thimann. Phytohormones. MacMillian Co., N. Y. 1937.

[1] Report of work supported in part by the Michigan State Agricultural Experiment Station, U.S.D.A., and in part by the National Science Foundation. Journal article 1855 from the Michigan Agricultural Experiment Station.

* Agent of Field Crops Research Branch, A.R.S., U.S.D.A.

[2] Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan.

ABSORPTION AND TRANSLOCATION OF RADIO-ACTIVE 2,4-D IN CERTAIN WEED SPECIES

M. C. Williams, F. W. Slife, J. B. Hanson[1]

Various broadleaved annuals show remarkably different responses to treatment with 2,4-D. Some are killed readily at very low concentrations; others respond, but are merely stunted, and do not die; while still others react only slightly at high concentrations, and quickly resume normal growth patterns.

Work was conducted on three annual dicotyledonous plants which are classic examples of the types of responses just mentioned. These are cocklebur (*Xanthium commune*), jimson weed (*Datura stramonium*), and the bur cucumber (*Sicyos angulatus*). The terms susceptible and resistant are used herein to denote the ease with which these plants are killed. The terms responsive and nonresponsive cannot adequately be applied, since some species which are not readily killed are highly responsive.

Initial work consisted of screening several annual weeds into classes of resistance by spraying plants at various stages of growth with 2,4-D amine at concentrations ranging from 100 to 1000 ppm. Cocklebur was the most sensitive species tested, and one on which a 100% kill could be effected within a few days with 100 ppm. of the herbicide. Jimson weed was not killed by treatment with 1000 ppm, but growth was immediately terminated followed by gross proliferation of the bud and stem. When concentrations of 2,4-D were increased to 2000 ppm, death of jimson plants in the 4-5 leaf stage would occur after approximately 30 days. In the bur cucumber, treatment with 2000 ppm. 2,4-D amine produced epinasty and leaf curling, but these effects, while fairly permanent on the treated portion, did not prevent recovery and additional growth of the plant. In a test comparing 2,4-D ester with 2,4,5-T ester, no deaths occurred when bur cucumbers were treated with 800 ppm. 2,4-D, but a 100% kill was obtained on plants treated with 30 ppm. 2,4,5-T.

Tests conducted in these species in nutrient solution indicated that resistance existed in relative proportions, whether the herbicide was absorbed through the roots or foliage. Cocklebur again proved most sensitive, a 100% kill provided by as little as 5 ppm. in nutrient solution. Jimson weed and bur cucumber, on the other hand, were only effectively killed at 75 ppm. *Datura* was stunted at all levels below 75 ppm., but the bur cucumber continued to grow at nonlethal concentrations.

On the basis of the above observations, one might logically assume that resistance was controlled primarily by failure of the herbicide to penetrate the vascular system of the plant, or if equal penetration occurred, that the rate or volume of 2,4-D transported throughout the plant varied among species.

Subsequent experiments involved the tracing of the absorption and translocation of C^{14} labeled 2,4-D throughout the 3 species. Plants were grown to the 3 to 4-leaf stage in the greenhouse. The top mature leaf was then ringed with lanolin and 0.02 ml. of 2000 ppm. carboxyl labeled 2,4-D was applied to the mid vein. The plants were sectioned at 1, 2, 4, 8, 12, and 24 hours. The upper half of the treated leaf was severed and discarded. The portions of the plant analyzed for 2,4-D included the base and petiole of the treated leaf, bud and immature leaf, each mature leaf, central portion of the stem, and base of the stem immediately beneath the soil surface. Duplicate plants were sectioned in the same manner, pressed, and exposed on kodak no-screen X-Ray film.

Following wet combustion analyses of the individual plant parts, it was found, contrary to expectations, that the resistant plants contained equal or greater quantities of C^{14} than did cocklebur. At 12 hours, the C^{14} content of the treated leaf, stem, bud, and roots of jimson and bur cucumber was nearly twice that found in cocklebur. After 24 hours, there was still an equal or greater amount. Radio-autographs from this experiment confirmed that rapidity of translocation of C^{14} in the resistant species was equal to or surpassed that observed in the cocklebur.

It was concluded that resistance was probably a physiological factor inherent within the plant and not necessarily dependent on the amount of 2,4-D actually absorbed and translocated.

Members of closely related species tend to exhibit similar levels of resistance in many instances. Cocklebur and sunflower are very sensitive, while Pennsylvania smartweed and wild buckwheat are classed as intermediates. Most members of the *Solanaceae* are highly responsive yet quite resistant to kill with 2,4-D. Even tomatoes, which belong to the same family, were extremely responsive to small concentrations of 2,4-D,

XUM

but were difficult to kill after reaching an intermediate stage of growth. Plants 10 inches high sprayed with 1800 ppm. 2,4-D have been found to survive a test period of 30 days.

In the species studied, it was found that age at time of application of 2,4-D was of little importance if the plant was sensitive, but that tolerance among the resistant species tended to increase with age.

On the basis of C^{14} studies, there is reason to believe that absorption and translocation of 2,4-D, at least among these species, is not a major factor in determining sensitivity or resistance. It appears the determining factors may be either what disarrangement the plant itself can effect on the 2,4-D molecule once it has been absorbed into the vascular system, or what chemical-physiological processes occur in the plant that renders the 2,4-D nontoxic.

Additional studies are under way to determine the rate of decarboxylation of radio-active 2,4-D once it is absorbed within the plant.

1 University of Illinois, Urbana, Illinois.

"HOW TO BRING ABOUT A BETTER AND MORE UNIFORM ENFORCEMENT OF THE WEED LAWS"

C. J. Gilbert[1]

Fellow Regulatory Workers:

Just how your chairman was influenced to ask me to speak on the above subject can only be explained by the fact that a man by the name of Sylwester is, at least partially, his boss, and when the boss says "Go get 'em," there isn't much else he can do. I will admit that I do owe much to Dr. Sylwester for his help in many ways, on many occasions, and for many things. He has reminded me in subtle ways about these unpaid obligations. If, in this way, I can just pay a little of the interest on that debt, I will be most happy.

However, the place is brimming over with talent from Minnesota, Iowa, Kansas, Nebraska, South Dakota and elsewhere, and I feel very humble and inadequate at this moment, discussing the above subject about which I would like to know more than I do. You see, this is an important meeting. Not only important to you, but to the folks back home and you are the only means that most of those folks at home will ever have to know anything about something good that we may say or do here. You are the transmission cable, the teletype, the bulletin board, the messenger of information, whether it be good or bad. If I or the other speakers fall down on the job, you might also do the same. So on you and me is placed a positive responsibility to folks at home. Your state government, your county government, your township and municipalities and each of your farmers should get results from these sessions to justify our existence as public servants and the programs that we are responsible for.

Those at home are depending on you to secure information for them; depending on you to bring back to them inspiration for the un-inspiring task of cutting down on the terrific agricultural loss caused by weeds; depending on you to develop in them the enthusiasm for doing well a tough job. That is why this meeting is important. Others are depending on you.

The topic assigned, "How To Bring About a Better and More Uniform Enforcement Of the Weed Laws," is a long one and I do wish I could wave my hand and say the first word in Indian fashion, "How" and let it go at that. But problems are not solved that way, nor is progress in a program built by going by "on the other side."

There are some things necessary for better and more uniform enforcement of the weed law—or any law. The first of these is public opinion.

ENFORCEMENT IS PUBLIC OPINION

A neighborhood leader in a county weed control program drove into a farmyard and asked for Joe. Joe's wife said Joe was about some place, probably out in the machine shed. She was right. Joe was doing some repair on the tractor mower. After the usual few casual remarks about this and that, the neighborhood leader said, "Joe, the folks around here had a meeting the other night about our weeds. The bad ones are getting worse and more of them every year. They make it tougher for you and me and all of us, to farm and get a decent crop, and they take too much out of what we do get. The folks elected me as neighborhood leader, to help get a picture of how many kinds of weeds we have on our farms, and the estimated acres of each kind. I haven't any more time than the rest of you, but some day, if we don't do something now, it will cost me, and you, a lot more in cash and a lot more in time than it will now. Have you any noxious weeds? And what luck have you had in killing them?"

At first Joe wasn't too sure it was any of the neighbors' business; he wasn't sure he wanted to tell anybody about his weeds; he wasn't sure he wanted to have any part in a weed control program; he wasn't sure that he was concerned about weeds, anyway. But when Joe found out that Andrew and Pete and Harry and John and Jake and the Hanson boys and fellows along the west fork were all trying to stop the spread of land-stealing weeds, he suddenly remembered (?) that he was an old time weed fighter and had been trying to get something started for a long time, where everyone would fight weeds. He, himself, vigorously said as much.

Public opinion expressed in the form of a neighborhood effort had transformed Joe, who at first wasn't sure of several things, into a cooperator, a supporter, a booster, and a weed fighter. Would he have been as willing to do battle against weeds, if an inspector had served him with a legal notice? If he had been referred to a clause in the law? If somebody had threatened to have the law on him? As it was, he became a friend of the weed control program and not an enemy, and he actually did help convince others to join the parade of weed fighting farmers.

Now this Joe is an actual person, but by and large we, too, are all 'Joes.' By and large we all wish to join a going concern; be part of a good movement; be a supporter of good things for the neighborhood; be a booster for a dollar making or a dollar saving program, if the others help too. Why deny ourselves the satisfaction of doing things the right way, the natural way, when the other way often gets so little done and with so much twisting of the souls of men.

Some fifteen men, weed fighters, who had noxious weeds, and admitted it, and were trying with all their might to get rid of the vicious plants on their own farms, did not take kindly to the one farmer in their neighborhood who seemed to not care about the Canada thistle just starting to bloom; or about the sow thistles, which would soon be, with the help of our ever-present winds, spreading seed to new land; or about the creeping jenny which would soon produce seed and be threshed with the grain and be spread elsewhere. He wasn't a bad fellow, but he didn't quite like to be told what to do or when or how he was to take care of his fields, even as you and I, thank God. He was difficult for the neighbors to talk to, they said. He forgot that noxious weeds, the kind where seeds blow from his farm to other farms and the kind that spread rapidly above and under-

XUM

ground, and fasten themselves tenaciously on good land, robbing it of productivity, adding to the cost of operation, dividing its value, multiplying its problems and subtracting from its returns, are **not** alone his business. They become the business, and I use that term advisedly, —they become the business of his neighbors and their neighbors and of all the people who till the land for a living, and those who depend for their living upon the returns from the products of the soil. So these fifteen farmers, who felt that they were doing their share, asked that something be done about the situation. To show that the neighborhood wanted action and would back the enforcing agent, they signed their names to a petition for enforcement. The petition was given to the county weed board, by the neighborhood leader, and after careful checking, the matter was referred to the weed supervisor. The supervisor went to the 'weed keeping' farmer first. We will call the farmer Andy, which isn't his real name. The supervisor opened the conversation with, "Some of the boys are saying that you are having trouble with your weeds. It looks like you do have some bad ones out there. What have you done to get rid of them? What luck have you had?" They talked for 20 or 25 minutes about weeds; the high cost of keeping them; how certain areas of that state and others had become overrun by these pickpockets of the land; how important it was to prevent them from spreading; how land values depreciated because of them; how some farmers had actually lost their land or abandoned certain areas because of noxious weeds.

Finally the supervisor said, "You don't know it perhaps, but there is a petition with a lot of names on it asking for weed control enforcement on your land. I haven't got it and I don't know whose names are on it. I purposely didn't read the names so I wouldn't know. I came to you first, because I thought you would appreciate my doing it that way. You don't want anyone else to do this job for you, do you? You don't need anyone else to handle those weeds, do you?" The answers were, "No," and then Andy said, "I didn't know the boys were putting on such a weed control program, and were so anxious about it. I'll get at those weeds right away. In fact, I talked to a man about spraying those thistles but he hasn't shown up." The supervisor asked who it was and was given the man's name. The supervisor asked Andy if he would like him to go and see the man with the sprayer and ask him to go down right away. Andy said, "Yes, maybe he will come quicker if you ask him." As the supervisor left, Andy came to the car and shook hands and said, "Thanks for being such a gentleman about this. Those weeds should have been taken care of. When you told me who you were, I expected to have you take the hide right off my neck. You have been very decent about this, and I will take care of those weeds. The other boys don't need to worry anymore because I'm with them."

The sprayer was contacted. The weeds were treated; the unsightly patches of annual weeds were also removed and a report in the fall of 1948 stated that this farm was in the best condition as to weeds that it had been for years. It was not the law, it was not necessarily the supervisor, it was not necessarily Andy's fear of financial loss, but it was public opinion that had most to do with weed control on Andy's farm. All of us, Joe, Andy, and You and I like to have public opinion think well of us. Public opinion, active organized public opinion, that says keeping noxious weeds is not good, and that a 'weed keeper' is, let us say, not a good neighbor, will get weeds killed and controlled. That it what we are after, isn't it?

There are thousands of good potential 'weed fighters' in your state who are waiting to go along with the public opinion of their neighbors, if the neighbors will tell them. It should not be kept a secret; it should be the subject of discussion at school functions, church socials, coffee time, filling station talk, farm clubs, farm organization meetings and soil conservation meetings, etc.

If our good crop acres can produce full crops, without weed competition, many acres of marginal, rolling land and land with light soil can go back to the grass it should always have produced, and thus make our livestock enterprises surer and safer. Many, many thousands of acres of land now in grass can add much to its carrying capacity of livestock, and its productivity of hay if the grass that it there does not have to compete with weeds.

A complaint lodged with a county weed board was referred to the county weed supervisor who went out to the farm of the complainer to get the low down on the situation. That is a good expression, because to a weed fighter, weeds are pretty low down! The sender of the complaint was seen and he told how the neighbor had noxious weeds and wasn't taking care of them. That was bad!! Both agreed to that definitely. The supervisor, in the meantime, had been looking around and had discovered that his informer had feet of clay! He, too, had some noxious weeds which were uncontrolled. The two of them looked them over, the farmer's face becoming more red by the minute. They found one kind of noxious weed that the farmer was unacquainted with and that day he learned of a new weed problem on his farm. He then asked that nothing be done about his complaint because he, too, was guilty but he would get busy at once.

Then the supervisor went to see farmer number two, the one against whom farmer number one had made the complaint. After asking about his weed problems, the supervisor called number two's attention to the unkilled weeds that had been the cause of the visit. They went and looked them over, discussed various methods of control and before the day had passed, another 'weed fighter' was in action. To make a long story short, as a result of that one friendly neighborhood call, five, not one, farmers—neighbors of each other—took care of their noxious weeds and some annuals.

Public opinion and the desire to go along with it, rather than against it, killed weeds in that neighborhood that afternoon. If there had been a neighborhood weed control unit, which had had a little meeting where all the neighbors could have seen colored slides of noxious weeds; seen mounts of noxious weeds; discussed methods, means and reasons for weed control; made plans for unified action; and planned a survey; that all important public opinion would have had everyone, or nearly everyone, supporting it instead of five people. Identification would have been easier; little patches would have been killed before they became big patches. Public opinion against thievery by weeds would have prevented costs and losses. Public opinion is enforcement

Another community that we know about did a remarkable job in developing a program for weed control, not perfect, but very good. Two people in that township, they said, and I can verify some of it, were the only non-cooperators. One, a widow, was not able to get the weeds taken care of because her sons "just never got around to it." But she "would get it done because it was the right thing to do and it should have been done before." She "didn't want the neighbors to think that she wasn't for the program, because she was for it. If all the land got as bad as that patch, nobody could farm."

The other 'weed keeper' was a man and he became arrogant when talked to; the fact that sow thistle and Canada thistle on his field were in blossom didn't bother him; he wasn't going out in sloppy weather to destroy weeds; he wouldn't damage crops to destroy weeds; in fact, he wasn't interested in killing weeds anyway. Then public opinion stepped into the picture. Two neighbors

XUM

were along, neighborhood leaders, and they told him about all the work they were doing to kill weeds on their farms; of the fine cooperation others in the township had given the weed program; to what lengths other weed fighters had gone to stop weed spread and they finally closed the argument of good public opinion by saying that they held in their possession a petition containing the names of 23 of his neighbors asking that his weeds be controlled. The arrogant man would probably have become angry at a law enforcement agent, but public opinion won. The arrogant one did destroy weeds in damp,sloppy weather; he did damage some crop to destroy noxious weeds; he did cooperate because public opinion told him it was the thing to do.

Enforcement is public opinion. Try it out sometime.

Then the question comes up—How do we get public opinion? First, there must be information, and this information must be given to the people—not just be made available. Posters, pictures, newspaper articles, pamphlets, circular letters, meetings, little meetings, big meetings, meetings in homes, rural schools, town halls, special meetings in menace areas, meetings with school children, 4-H Clubs, with vocational agricultural teachers and students, Crop Improvement Associations, farmer elevator groups, line elevator managers, chemical sales people and distributors, and on—ad infinitum. Nothing to do in the winter time? There are more opportunities in your county to build public opinion against noxious weeds this winter, than you will ever get done, but go to it and try to do it anyway.

Information as to the cost of weeds, difficulties of killing them after they are established; added cost in harvesting, loss in crops, loss in dockage, costs in extra cultivation, costs of necessary chemicals and added cultural practices; loss of farm value, loss in income per farm, per cummunity, in the county, in the state. We tell our people that a good weed control program will save the cost of total county government **every** year. And then there must be **good** information as to how to do the job of control and eradication. This comes from experimentation, research and field observation.

What is the path by which this information travels to develop public opinion? It is organization. Organization of people into groups, neighborhood units, communities. Use the ones that are there, or develop new ones. But there are always a very few people that do not care about public opinion. Not very many, but a few. When one of these comes into the picture, enforcement of the statute must be the procedure. It must be good. He must have been seen and contacted previously so he can't say "I didn't know." I think that a newspaper notice is not enough. He should be put in a position of refusing to go along with the weed control program, so that he hasn't got a number of sympathizers. His neighbors should, down in their hearts, want those weeds destroyed. Enforcement should be firm, positive, carried through promptly by an enforcement agent who has guts, courtesy, ability, and who has respect for the law he is enforcing. One well-handled enforcement case will stop a dozen more that will surely come up to plague you if the case is not handled well. A namby pamby approach by a scared or by a politically, expediently directed agent will cast discredit on you, your program and your weed law.

Be fair; be firm; be fearless. Be right; be positive; this is just as important to good enforcement as it is to be patient, persistent, persuasive and have perseverance before you start enforcement. The people must have respect for your law—both your cooperators and the non-cooperators.

To summarize:

1. Secure good, solid, active, positive public opinion.
2. When you have to have a legal procedure to secure compliance, make it positive without equivocation and without deviation.

Thank you.

1 South Dakota State Weed Board, College Station, South Dakota.

CANADIAN SEED GRAIN SURVEYS

T. V. Beck [1]

In this age of scientific advances in weed control it is still of prime importance to consider one of the fundamentals of weed control, the use of clean seed. With a view to focusing the attention of farmers on this important fact a number of seed grain surveys have been conducted in the Canadian Prairie Provinces. Seed grain surveys not only determine the condition of seed grain being used but, more important, the publicity accompanying them does a great deal to create an interest in the use of better seed and seed cleaning equipment.

For the purposes of this paper I have selected the larger of the most recent seed wheat surveys in the three Canadian Provinces, these include: Saskatchewan 1953, comprising a total of 1374 samples from 41 municipalities; Manitoba 1954, a total of 335 samples; Alberta 1955, 1362 samples from 17 districts. These contain a variety of information including use of recommended varieties, purity of variety, presence of smut, use of disease and insect treatments, use of weed chemicals etc., but only material relative to weed seed content and seed cleaning will be presented here.

The first information obtained in these surveys was the grade of seed being sown as reported by the farmer. Registered and certified seed refers to seed which passed field inspection and for which registration certificates have been issued. Commercial seed is seed for which a control sample certificate is available.

Grades of Seed Sown

	Man.	Sask.	Alta.
Registered or Certified	8	3.5	2.0
Commercial	20		
Ungraded	72	96.5	98

Figures indicate percentages

The results from Manitoba are slightly better than those from the other provinces, but all leave much to be desired. It is much more serious when we consider that in Saskatchewan alone 4,000,000 bushels of Registered seed is produced yearly of which less than one quarter is used for seed in that province.

The second information obtained was with regard to source of seed, as shown by the following table:

Source of Seed

	Man.	Sask.	Alta.
Home Grown	80	87	71
Other Farmers	15	11	23
Seedhouses, elevators and registered growers	5	2	6

Figures indicate percentages

The interesting figure here is the amount of seed purchased from the other farmers, an average of over 15% in the three provinces. In the Saskatchewan survey it was found that the average seed purchased from other farmers was no better quality than which was home grown.

The most important information was the official grading of samples. In all three provinces the same standards those of the Canada Seed Act were used. To grade rejected, the minimum number of weed seeds per pound would be 3 primary, or 15 primary and secondary, or 100 total weed seeds, or 50 other crop seeds. Minimum germination is 65%.

Official Grading of Samples

	Man.	Sask.	Alta.
No. 1	11	13.9	38
No. 2	26	16.8	11
No. 3	22	26.6	17
Rejected	41	42.7	34

Figures indicate percentages

XUM

Of particular concern is the large percentage of seed which fell into the rejected category. Although rejected seed is considered unfit for seed purposes almost 40% of the farmers in these three provinces were using it. It is also regrettable that another 21% were using No. 3 seed which is the poorest grade of seed which can be offered for sale in Canada. Therefore a total of over 60% of the seed being used can be regarded as definitely below good seed standards, most of it because of weed seed content.

Further information concerns the type of cleaning employed by farmers. This information is shown in the following table:

Method of Cleaning

	Man.	Sask.	Alta.
Farm	58	37.8	58
Rejected	45	36.1	41
Elevator	38	43.0	8
Rejected	74	54.8	45
Portables	4	10.7	10
Rejected		32.6	17
Local plants			9
Rejected			17
Stationary plants	1	6.0	13
Rejected	16	8.7	13

Figures indicate percentages

The fact that an average of 58% of the seed cleaned in country elevators graded rejected indicates that this type of cleaning should be strongly discouraged. The figures also show that there is room for a great deal of improvement in farm cleaning methods since over 40% of farm grain was shown to be unfit for seed. It is also obvious from these figures that one of the answers to the seed cleaning problem is the erection of more seed cleaning plants. Alberta has taken a great step in this regard by assisting with the erection of such plants. The results of this have shown up in a series of seed grain surveys conducted over the past seven years shown in the following table:

Alberta Seed Grain Surveys

Year	No. 1	No. 2	No. 3	Rejected
1949	21.5	10.0	17.5	51.0
1950	32.0	9.0	19.0	40.0
1951	26.0	17.0	17.5	39.5
1952	28.3	15.3	15.2	41.2
1953	33.0	12.0	17.5	37.5
1954	31.5	14.0	17.0	37.5
1955	38.0	11.0	17.0	34.0

Figures indicate percentages

This gradual improvement from 51% rejected in 1949 to 34% in 1955 can be largely attributed to more and better seed cleaning facilities.

The quality of work done by central seed cleaning plants is shown in the following table from the 1953 Saskatchewan Seed Survey. The municipality of Eston, Saskatchewan is served by a well operated and efficient seed cleaning plant while the R.M. of Weyburn is served only by elevator and farm cleaning facilities.

Grades	R.M. of Weyburn	R.M. of Eston
No. 1 Seed	2	27
No. 2 Seed	0	7
No. 3 Seed	3	4
Rejected	35	2
Total samples	40	40

It was also noted that only one of the rejected samples from the Eston municipality was cleaned at the plant, the other was cleaned at a country elevator. The forty samples cleaned in the plant showed a total of only 50 weed seeds and 2 barley seeds. We only need to compare this with one farm cleaned sample which contained 826 weed seeds and 24 seeds of flax to give some idea of the value of seed cleaning plants in weed control. The latter farmer was seeding approximately 75,000 weed seeds per acre.

In conclusion it might be stated that the Canadian Seed Grain Surveys have served several valuable purposes. They have:

(1) Pointed up the deplorable condition of seed grain stocks with regard to weed seed content.

(2) Pointed up the inadequacies of country grain elevator cleaning.

(3) Shown the need for more efficient farm seed cleaning methods and equipment.

(4) Shown the adequacy and value of stationary seed cleaning plants and aroused a great deal of interest in their construction.

(5) Provided information for an intensive educational campaign by all agencies interested in crop improvement and production.

[1] Saskatchewan Department of Agriculture, Regina, Saskatchewan.

STATE WEED LAWS IN ACTION

Vernon W. Woestemeyer[1]

The subject I have been asked to discuss is "State Weed Laws in Action," and when you begin studying what has been accomplished as a result of the weed laws of various states and provinces in the North Central Weed Control Conference, the only conclusion you can draw is that these weed laws certainly are in action.

There are several differences we might point out in comparing the laws: We are not all concerned with the same weeds—which is logical in view of the fact that ecological factors vary so much within the North Central area. Bindweed comes the nearest to being a universal problem as far as weed laws are concerned, and apparently it is more difficult to control in some areas than others—at least it seems to give us in Kansas more trouble than it does some of the rest of you.

There are differences in the procedures for bringing weeds under the purview of the weed laws of the various states—from the Oklahoma law in which only bindweed is included, to the Minnesota law under which the term "noxious weeds" may include any plants that are injurious to public health, roads, crops, livestock and other property.

The South Dakota law provides for weed research and extension work in addition to the activities of the State Weed Board and the State Department of Agriculture, which is different from the laws of other states.

Methods of control are determined in various ways and provisions for enforcements vary. In Kansas, County Weed Supervisors or County Commissioners serve legal notices to errant landowners with noxious weeds. In South Dakota enforcement is a function of the State Department of Agriculture. The most extensive enforcement procedure in our area to my knowledge is that of the provinces of Manitoba and Saskatchewan, where the law provides for the weed authorities to take over infested property for 5 years and apply control measures. Under this procedure records are kept on each farm. If a profit is shown during the 5 years, it is returned to the landowner, and I understand that in some instances the profit during the eradication period has exceeded that of the preceding years, in spite of the added costs of weed control.

There are many other differences that could be mentioned, but they are all minor when compared with one point the laws have in common, which is their objective—to control and eradicate established

XUM

stands of noxious weeds, and prevent their further spread. This can be done only through action on the part of all concerned—state and local officials, individual farmers, landowners, feed dealers, etc. Satisfactory results depend on an earnest effort and a spirit of cooperation all the way down the line. Any of the control methods we use can serve as an example. The research people develop and recommend them. The state office passes them on to the local weed supervisors who use them, and get them used, out where the weeds grow. This is where the truly effective "action" takes place, and there's a lot of it. In Nebraska, in 1954, which is the most recent year for which data are available, over 100,000 acres of noxious weeds were treated. In Kansas last year over 110,000 acres of bindweed alone were treated that we have record of. In South Dakota, it is estimated that 60% of the bindweed acreage is being controlled in addition to all of the other noxious weed work. Minnesota used about 1½ million pounds of soil sterilants in addition to the other herbicides. Over 28% of their grain acreage was sprayed, and also a 200 acre lake. If we were to check these figures against those of ten, or five years ago, we would find we are covering several times the area now that we did then.

One of the difficult problems we are all faced with is that, unfortunately, we still don't have the perfect one-treatment, safe, economical chemical. We have several good ones, but we still must plan each year to check back on previous treatments and follow thru with re-treatments if necessary. In Kansas over 7,000 visits were made for this purpose in 1954. This takes quite a bit of time, but it is more important to follow thru on unfinished work than to start new treatments at the expense of leaving work that has been previously started incomplete. Certainly it is difficult at times to convince someone on this point, but it is a policy we must adhere to.

For a satisfactory noxious weed program, we found, as you folks did in your states, that it was futile to kill out existing stands of noxious weeds if at the same time we allowed seeds of these same weeds to be scattered and spread over the state without any restrictions. So, as a complement to the original control and eradication provisions, our law was amended to prevent the spread of noxious weed seed thru infested material and custom machinery, as many other state weed laws do. This phase is possibly more important to us in Kansas than it is to some of you, because we import so much feed grain. We import some hay, too, but not nearly so much as we do grain—mostly oats.

The following data for 1954 explain our concern over this matter. There were 1,190 carloads of feed grain inspected during the year, prior to shipment into Kansas and 491 of these—over 40%—were found to contain field bindweed seed. These loads were not delivered into Kansas. During that year we also inspected 5,757 truckloads of feed grain coming into the state and rejected 493 of these loads, or slightly under 9%. The explanation for the much lower percentage of infested material in the truckloads as compared with the carloads lies in the fact that the truckers are aware of our law and our inspection procedure and they try to select clean grain to bring into the state, whereas the carload inspections are made without much of an opportunity to do any selecting before the cars are inspected. I was interested in some figures for the state of Nebraska for 1954. There were 1,140 lots of feed, mostly truckloads, inspected for noxious weed seeds and 100 or approximately 9% of these were found to contain noxious weed seeds. I don't have data from the other states in the area but do know that Oklahoma and most of the other states with noxious weed laws do have active inspection systems.

The figures I gave you for Kansas a moment ago were on interstate movements of feed material. Recently an elevator operator asked me why we pay so much attention to interstate shipments when there was a lot of feed moving around within the state. He was quite surprised to learn that our intrastate inspections number larger than those for interstate. Our county weed supervisors made over 11,000 inspections of a local nature covering material offered for sale by farmers, at community sales, and other local places.

We all realize the importance of custom machinery of various kinds in our present-day agricultural operations. These custom machines also present a problem insofar as the spread of noxious weed seeds is concerned. This was a poor year for wheat in Kansas, but during the harvest season we inspected 1,097 custom combines coming into the state and didn't find a one with noxious weed seeds in it. This is quite different from our results of a few years ago when this inspection program was initiated. At that time the combine operators were not cleaning machines before they came across our state line. The word spreads pretty fast, however, and even by the end of that first season machines began to come through in pretty good shape. In each following year we have observed that more machines have come through cleaned and this year was the best yet. I have some figures from Nebraska that are somewhat disconcerting to me, though. In 1955 they inspected 3,310 combines coming into the state and found 3,052 to be cleaned, 175 partially cleaned and 83 uncleaned. The operators of these 83 machines were fined in court. The disconcerting thing is that several of these machines probably came to Nebraska from Kansas, which means that they probably did a little work in our state when they were not clean. The one consolation that I have been able to detect is that there is a little difference in our laws so far as custom machinery is concerned. Possibly the uncleaned machines that came from Kansas to Nebraska did not contain any noxious weed seeds, even though the machines were not clean otherwise. At any rate, I hope that is the case. I have no data on South Dakota's inspection work along this line for this year, but do know that the state has had an active program and an influence far beyond the state boundary. I have seen South Dakota tags on several combines that were checked in Kansas and the operators remarked that they knew the machines had to be cleaned before they could go into Nebraska or South Dakota, and they expected us to be checking, too.

Drill box or seed box surveys are another illustration of an activity that calls people's attention to the need for precautions, if a farmer or landowner is going to protect his land from a potential noxious weed problem. Surveys of this type were taken in several states. The laws vary considerably as to the noxious weed seeds for which the samples were examined, but nevertheless the results are quite interesting. In Minnesota 486 drill box samples were taken and analyzed during this past season. Ninty-one violations were found and 18 samples were found to contain prohibited seeds. In Wisconsin 258 samples were taken and 207 were found to contain noxious weed seeds. I'm not sure whether these are all prohibited seeds, or whether some are considered noxious but are in the restricted category and not prohibited. Nebraska was one of the first states in the area to conduct a drill box survey. After they assembled the data, they took the figures right back to the farmers and showed them what was being done. This should be considered a "must" if we are to get full benefit from the survey.

The things I have mentioned so far are those that appear to be of rather universal importance among the states in this conference area that have active noxious weed programs; however, there are many local situations and many important activities that are carried on in various states that are not common to all. One problem that the Northern states in the conference have is tax exempt lands on which some serious noxious weed problems exist. In many cases they pose a con-

XUM

stant threat to adjacent private land. In Minnesota action has been taken in a limited way through an appropriation made by the state legislature to control noxious weeds on some tax exempt lands. Some has been used on state and local land falling in this category and some has been used on Federal land. In South Dakota, the problem has twice been brought to the attention of the House Agricultural Committee in an effort to get some federal assistance with the problem.

This is one problem for which the conference has gone on record as urging the Federal government to recognize and provide assistance. Another conference resolution urges the enactment of Federal legislation to aid the states by requiring feed and other materials moving in interstate commerce to comply with the weed laws of the states to which they are consigned. Both of the above resolutions came about because of active state weed control programs.

One of the principal responsibilities and activities of the various state weed departments is to train, educate, and assist the local weed officials, both with technical problems and those concerned with enforcement. This is accomplished by holding state and district meetings, local meetings at the county, town, or township level, and making visits to individual farms. Many of you are familiar with the publications of the South Dakota State Weed Board, the "Weed Fighter" and the "Weed Control Workers Handbook," and the "Bindweed Eradicator," published by the Noxious Weeds Division of the Nebraska Department of Agriculture. These provide an excellent means for getting timely information out to local weed officials, and for exchanging ideas. Several state departments have taken advantage of opportunities to participate in radio and TV programs, and have also made good use of the newspapers by sending out general news releases. I have received copies of several releases from Wisconsin that could not help but stir up some local interest and action. I also know of several instances where county agents and county weed supervisors have used regular newspaper columns to keep people informed and interested in noxious weed work.

We in state work use the means I have discussed here, plus a good many others, to make the most of these various approaches to maintaining and furthering noxious weed control programs. Nevertheless, it soon becomes apparent that the success of a noxious weed program rests primarily with the local communities. We cannot overlook the importance of having local weed officials with good qualifications and lots of ability. I know of instances, and you can think of some too, where county programs have risen from very mediocre to excellent for just one reason—a change in county weed supervisors. No less important, however, are the individuals who make up the community. The success of any large program is dependent primarily on all of these local people, and state weed programs are no exception. Let's talk to them, listen to them and work with them, and get still more action from these state weed laws. Those of us who work out of state or regional offices can assist local officials and individuals in a good many ways, but the fact remains that the action that kills the weeds is right down at the local level in the many communities throughout the country.

[1] Kansas State Board of Agriculture, Topeka, Kansas.

TEACHING AIDS

Keith Wallace[1]

The use of teaching aids in weed control educational work, like in any other field, is very helpful in putting across a point. However, preparation of these aids involves a great deal of work. For this reason they are not as abundant as we would like to see them.

In this ta'k my aim is to present ideas that you can take home and put into use. Some of you no doubt are already acquainted with at least some of of the material to be presented. Many of the visual aids are quite cumbersome, therefore in order to facilitate presenting them to you I have taken pictures of them and will present them to you on slides. This immediately brings out the reason why so many of us are using slides rather than some of the other visual aids. With this in mind the first item is on preparation of slides. It is the use of food coloring to stain black and white slides, giving them more life as well as being easier on the eyes, (complete directions may be obtained by writing to Extension Visual Aids Department, S.D.S.C., Brookings, South Dakota). Next are samples of slides on identification of plants and seeds that have been used extensively in the South Dakota weed program.

Listed below are the other visual teaching aids to be presented:

1. A portable lectern with a built in P.A. system. Although it is not a visual aid it is relative to the problem of getting the point across. This stand folds up to about the size of a brief case and includes a light as well as the P.A. system, both of which use 110 volt current. (This lectern was built by Milo Potas, Extension Visual Aids Specialist, S.D.S.C., Brookings, S. D.)
2. Weed seed identification board—Samples of weed seeds are arranged permanently under glass or other transparent material, around the perimeter of an 18x24 inch board. A mixed sample of crop and weed seed can be placed in the center of the board where it can be sorted out and identified with the aid of the weed seed samples. Another idea comes from A. F. Shaw, Extension Agronomist from Montana State College. This display represents one bushel of seed wheat. The contents were divided to show the amounts of the following: clean seed, noxious weed seed, other weed seed, other crop seed, chaff and broken seed, and inert matter.
3. Flannelgraphs or mohair boards. The mohair board presented here is an innovation of the extension visual aids specialist at S.D.S.C. It is a variation of the flannelgraph but is covered with mohair instead of flannel and has the advantage of carrying 3 dimensional objects that are too heavy for the flannelgraphs.
4. Bell ringer identification exhibits. The bell ringer is a device using numbered mounts of weeds. When the individual identifies a weed by matching the number with the proper name a bell or light is activated.
5. Displays for state or county fairs, crop shows. A variety of items may be used for this purpose but one item that is outstanding is a full sized weed mount. In S. D. we have used two variations of this. The first being a mount four feet high and from eight to twelve feet long with a number of plants and their connecting roots mounted showing the way perennial weeds spread. The other variation is a mount four feet high and sixteen inches wide with one or

XUM

two full sized plants mounted in it. Potted plants are also used on some occasions, however difficulty has been encountered in keeping them alive.

6. Posters of individual weeds have been used to an advantage as a method of acquainting more people with the problem. They have a definite place in a well balanced weed educational program.
7. Bulletins of course are standard equipment in any educational program of this type. One variation of the leaflet is the printing of sprayer calibration information on tagboard so that it can be tacked up in the farmer's shop.
8. In western S. D. 4-H Club plant collections have played an important part in teaching weed identification. In the process of collecting, mounting and identifying the 4-H Club member learns about the plant and at the same time prepares a reference that can be used in the future. This 4-H project is one of the best aids the S. D. weed program has.
9. Chemical demonstration plots may be used as a means of teaching the physical properties of the various chemicals as well as their effect on weeds. This is probably the most widely used aid in weed control educational work. In order to be most effective it is essential that the plots are plainly marked, first by a large sign telling people that it is a chemical weed control demonstration, and second by a sign in each plot giving the chemical and rate and date of application.
10. Field demonstrations or tours are the last educational aid I have to suggest. Sprayer calibration, or application of soil sterilants can be demonstrated, and tours of demonstration plots and weed menace areas are one of the best ways to develop interest in weed control.

Undoubtedly there are other educational aids being used but this will give you a few ideas that may help you step up your weed educational program.

[1] South Dakota State College Extension Service, College Station, South Dakota.

WHAT COUNTY AGENTS EXPECT

Walter E. Spilker[1]

A supervisor of mine once said, "A good leader expects things to be done, but doesn't demand that they be done." We hope that suggestions in this paper may be taken in the light of the county agent as a good leader. We hope, furthermore, that by highlighting some of the things a county agent expects, we may help to carry out the important purpose of this conference.

First something about the county agent's job. The county agent would expect people to consider his job as one of assistance in dealing with the facts that help people to help themselves. Whether his work be with individuals or with organized groups, his primary aim is to provide the latest and best information that can help solve the problems at hand. He works under the direction of a county extension board which represents the broad field of agriculture and home economics. Through the extension board he has the challenge of a wide range of interests and problems. He wants to serve these interests, and today—more so than ever—he faces the very important problem of organizing his own work so he can do justice to any part.

Fortunately, weed control work has kept a prominent place in the county extension program. The agent expects to continue to give it prominence for several reasons. First, weed problems affect a lot of people. Secondly, he feels that he can handle weed control information—thanks to specialists and others who are there to help him. Thirdly, experience proves that farmers can do something about weeds. Furthermore, the results of weed work and more especially work pertaining to annual weed control are satisfactory to the farmer. The last consideration is most important because good extension work is accomplished if the results are satisfactory to the cooperator.

We may illustrate the importance of satisfactory results in eradicating animal disease, for example. We know that the sale of an entire herd of dairy cows will get rid of Brucellosis. But such a program forces the dairyman out of business. The results of such a program are unsatisfactory to him. He would rather eradicate the disease and keep the cows. Unless he can, he may be reluctant to cooperate. The agent expects to choose projects on the basis of how the results will be accepted by the farmer. Let's examine bindweed control. Bindweed has been a menace for a long time, and is still a potential menace. Its spread was so alarming that laws were enacted to compel eradication. It has been known for some time that sodium chlorate will kill bindweed if applied in proper amounts, but a complete sterilization of the land takes place. There is an accompanying fire hazard and danger in handling. Prospective results, satisfactory for bindweed control, were in some cases unsatisfactory for the farmer.

Should the farmer decide, as an alternative, that he would practice clean cultivation, he could effect control but he might have to forego a crop. The result is a loss of crop and immediately lowered income. This, to him, may be an unsatisfactory result.

Or take the tenant farmer to whom it is proposed that he eradicate the noxious weeds. Experience may result in an investment of time and money, and while he may be promised lowered cost of rent to compensate, he might lose the farm because of sale.

We might go on citing examples of apparent lack of cooperation or disinterest which might be explained if we understood better the feelings of the farmer and how he evaluated the results in terms of his own desire for satisfaction. It would seem also important that laws compelling weed control and eradication will be difficult to administer or even fail in achieving their purpose—unless results of enforcement are going to be satisfactory to the individual.

Of course, the method proposed may not be sound or foolproof. For example, 2,4-D has not given as satisfactory results in bindweed control as expected. It is not only important to know how to do a job, but also important to consider the effects of the results upon the thinking and action of the farmer. Thus, the application of information is one of the big problems a county agent expects to encounter. The extension educational job is not complete until the information is applied and the results are satisfactory.

For a moment, let's take a look at the agents' reports to see what they say they are doing in weed work. A random check reveals that all are doing some work on weed control. There is some variation in the write-ups. It is apparent that some consider weed work more important than others. Some show considerable planning, others do not. Here is an excerpt from a 1954 report.

"A very active weed control program has been conducted in this county the last 7 years under direction of the supervisors of the noxious weed district, with assistance of the reporting agent. Many news stories, radio broadcasts, and county and community meetings have been used throughout the county to promote and carry on the program. In addition to the publicity

XUM

work used to promote the program, demonstrations and control plots have been conducted the last 4 years. The State Weed Office has cooperated with the county extension service and the noxious weed district in conducting the tests, etc." Then the report goes into more detail on what was done.

The large group and mass media approach is typical county programing. It reaches more people in less time than other methods. For that reason the agent would expect to continue this approach. Yet, he would admit that some of his best work in any phase of extension is done out in the fields, up near the stage at the close of a meeting, or in conference at his office. If this closer contact gets better application of information through explanation of possible alternatives, weighing all of the factors involved, some thought should be given to weed control programs of today.

Planning for better weed control is not a one-man or one-organization job. It is a job for all. The effects of neglect, carelessness and the like are reflected throughout a whole area. The agent would expect to assist a broad cross section of the interested people in planning for better weed programs. Program planning cannot be overemphasized. This is not time **spent** in control and eradication. It is time **invested.** It will produce a return upon the invested time.

Those who would invest their time in furnishing the leadership should take a close look at the job of weed control today. There has been much progress, but problems still exist.

An agent expects to get out the "road map," now and then, to take a critical look at the situation. He would expect leaders to look it over with him. To make such a job sound as simple as possible, we might suggest these questions for consideration:

1. What is the situation?
2. What would we like the situation to be?
3. What problems do we face in getting where we want to be?
4. How shall we proceed to solve the problems?

We can recall some fifteen to twenty years ago that a survey of noxious weeds, required for organization of districts, gave excellent account of the situation. It did more than that! It involved farmer to farmer contact. It helped to promote the war on weeds and gave weed supervisors a check sheet to note progress of the work. Agents would expect to make good use of information obtained from surveys in planning for weed control. This is the place to look at results. What results have we obtained with present methods should be answered. Perhaps more of this kind of information is needed now.

A short look back to the situation and a long look ahead to a goal is the next step. The county agent would expect to set some goals or stakes. These stakes would not only help measure progress, but would represent a challenge. It would focus attention upon the second point—that of where we want to be.

Now, the third consideration sets out the problems that must be dealt with in reaching the goals. County agents would expect the people to present these as they see them. Some might appear as definite road blocks, others just rough spots. At any rate, problems must be solved if we expect to get where we want to be.

The fourth point, how shall we proceed to solve the problems, is the real challenge for us in planning for better weed control work. Here the agent would expect to recognize the educational, regulatory, and service problems in weed work. Since his job is educational, he would expect to give most attention to that job. But he expects a close coordination of all three phases of weed work.

In the educational job, an extension specialist is a county agent's right-hand man. The agent expects the specialist to keep him up on the latest research information. He expects to call on the specialist for help at any time. He appreciates this contact with the College of Agriculture which keeps him informed, suggests new or different methods, and helps him evaluate his work.

The state weed supervisors may also play a specialist's role in weed work. Very helpful circulars and sources of information have been provided by the state departments of agriculture. This has been done in addition to their responsibility in regulatory work and planning assistance. County weed district supervisors, district managers, and extension leaders should team closely with the extension specialists and the state supervisors in formulating plans and carrying them out.

Visual aids are expected to get more and more attention by county agents and district workers. Visual aids arouse interest and stimulate thinking about as well as anything an agent uses in his work. He has found response from television to be good. One reason is possibly the good uses of visual aids. The agent expects to use the best visuals possible in identification work, and practices that control infestation. Perhaps color in weed identification manuals would be valuable in making the manuals more useful for individual or group discussions. Four-H Clubs would welcome such material. Of course, 4-H Club work provides opportunity to promote good weed control work. The clubs should not be overlooked in accomplishing the long-range program.

The agent expects to interpret technical information as simply as possible. Every effort should be made to design material for better understanding. This is a challenging job in weed work. No need to point out to weed workers here that the field of chemical control involves a lot of information generally understood by research and extension and other technically trained people, but extremely difficult for the average person. Keeping the information in readable and understandable form is a part of keeping up with the job. They cannot be minimized in getting good results from educational programs.

The service features of weed control comprise the third important aspect. Service goes along with educational and regulatory work as offering a more complete approach to the weed problems today. Local supplies of effective chemicals, facilities for seed cleaning, and supplies of clean seed are important in county programs. The agent would expect the county program to include the consideration of these services, but would not want to become so involved with them that he would have to sacrifice time of other phases of his program. He expects to refer people to others for service and appreciates the part service plays in the teamwork essential to weed control.

In summarizing what the county agent expects, it can be reemphasized that county weed control programs should be reviewed from time to time. Program planning is an investment of time that will pay big dividends. The overall or mass media approach in educational work is good and can be improved with modern methods. The possibility of working more closely with the people should be explored. Let's not overlook the value of helping people personally to help themselves. There may be more good done in the long run by getting out on the land and assisting people in the light of circumstances that prevail on that particular farm. There is value, too, in working more closely with organizations and other groups who have interest and responsibility. In other words, let's get closer to the job. Many advances have been made through research, and more will be made. We should give encouragement to those who provide the newer information that makes for efficiency on this job.

1 University of Nebraska Extension Service, Lincoln, Nebraska.

REPORT OF STUDIES OF A METERING DEVICE AND VENTURI TYPE DISTRIBUTOR FOR AGRICULTURAL AIRCRAFT[1]

J. E. Henry[2]

There has long been a need for a device that will effectively control the flow of dry materials such as dust, seed and fertilizer from the hopper on agricultural aircraft. Most of the present equipment simply has an adjustable slot on the bottom of the hopper and an agitator to help keep the material flowing. With this equipment it is difficult to get the desired or even a consistent flow rate.

Fluted Feed Device

The work on this problem has been almost entirely on the fluted feed type of device. Other types of devices considered included the auger, conveyer belt, rotary scoop and vertical impeller.

A fluted feed device with a 5" diameter rotor 20" long has been built and installed in a Piper J-3 airplane. It has rubber tips on the vanes to prevent flow when the rotor is stopped and a finger-like attachment over the outlet to even out the flow at slow rotor speeds. The flow rate, governed by the rotor speed, is quite steady and consistent from 10 rpm to at least 180 rpm when using wheat or granular fertilizer. The flow rate would be about 75 lbs. per minute at 10 rpm and 1200 lbs. per minute at 180 rpm, when using granular fertilizer. Lighter weight materials would give correspondingly lower flow rates.

When using dust the flow is not as consistent because it usually does not flow freely and its condition keeps changing. Diffusing low pressure air into the bottom of the hopper to agitate or "fluidize" the dust helps considerably.

Hydraulic Drive

With the fluted feed metering device it is necessary to have a variable speed drive which should be easily controlled, quick starting and stopping, efficient, and light in weight. With these requirements in mind it was decided to use a hydraulic drive.

A system was assembled consisting of a pump, motor, reservoir, filter, pressure compensating flow control valve with a built-in overload relief, and a small on-off (unloading) valve.

The flow control valve controls the flow by keeping the pressure drop across an adjustable orifice nearly constant. In addition to keeping the motor speed relatively constant, regardless of the load and pump speed, maximum torque is available for starting even when the valve is set for very slow motor speeds.

Since the engine did not have any provision for driving auxiliary equipment, a V-pulley was fitted to the propeller hub to drive the pump; however, it could possibly be run by a windmill if desired. The maximum power requirement for running the pump is about 3 horse power.

Distributor Studies

The work on dry material distributors for agricultural aircraft has included wind tunnel and flight studies (now in progress). These distributors are of the ram air or Venturi type.

The ideal function of the distributor is to give the material being applied sufficient velocity and proper direction so the desired swath width and distribution pattern can be obtained. Some of the factors that affect the swath width and distribution include the natural air currents (thermals, winds, etc.), air currents caused by the aircraft itself, aircraft speed and altitude, type of material being applied, application rate, and the distributor design.

Wind Tunnel

Because of the many variables involved and the difficulty of calculating particle behavior it was decided to start with a wind tunnel study. A wind tunnel and an adjustable test section of a Venturi type distributor were designed and built. The distributor test section and wind tunnel have clear plastic sides for observing and photographing the action. In order to actually measure the particle velocities and study the action more thoroughly, high-speed movies (1800 frames per second) were taken. The air velocities and static pressures were measured with pitot-static tubes and differential monometers.

The tests were run at several air speeds, material rates, distributor sizes and Venturi shapes. In most of the tests wheat was used as the material, although a dust and several fertilizers were also tried. The results obtained indicate that all these factors affect the velocities of the air and particles of material being applied which no doubt affects the swath width.

The conditions which contributed to the higher particle velocities were high air speeds, low material rates, large distributor sizes and slight or no Venturi shape.

In order to estimate the swath width resulting from the velocity given to the particles in the distributor an attempt was made to calculate the drag, vertical displacement and horizontal travel of ⅛ inch vetch seeds. Also, a device was used for throwing wheat seeds at various speeds from various heights. The horizontal distance traveled was measured.

Flight Studies

The distributor studies are now being carried on in the form of flight studies. Some of the variables being studied include the distributor length in front of and behind the deflecting vanes, radius of the deflecting vanes, and outlet angle. The effect of varying the application rate, aircraft altitude and airspeed are being observed.

The distributor and metering device were mounted on a Piper J-3 airplane. Granular fertilizer and 30-60 mesh clay insecticide base are the materials being applied in the tests.

From the information obtained so far the widest swath was obtained with the larger radius deflecting vanes placed closely behind the meter discharge and with a straight section extending beyond the deflecting vanes. These conditions gave an effective swath of 50 feet at 100 lbs. of granular fertilizer per acre and a 35 foot effective swath at approximately 50 lbs per acre of the 30-60 mesh clay. The airspeed was 75 mph and altitude 25 feet.

1 A summary.
2 Department of Agricultural Engineering, Ohio Agricultural Experiment Station, Ohio State University, Columbus, Ohio.

INSTALLATION AND PERFORMANCE OF A HYDRAULIC DRIVE IN A PIPER PA-18A[1]

Neal E. Shafer[2]

Fan-driven pumps are the most common type of spray installation being used on agricultural aircraft in our Conference area. Such a pump system to deliver spray solution to various distribution devices was first described by Husman *et al* (3) as a result of work done in 1942 and 1943. Hedden (2) and Isler (4) also list an external fan as a power source for the solution pump in their respective reports describing spray equipment for the Piper J-3 and Stearman N2S airplanes. Hydraulic power units

XUM

were tested by Young (5) in 1953 to obtain various performance data such as hydraulic pump and motor speeds, hydraulic pressures needed, centrifugal pump speed, spray pressures developed and rates of discharge. Laboratory mock-ups indicated a V-belt could be used as a means of deriving power from the engine thus suggesting the possible utilization in connection with the smaller aircraft engines where adaptation to an accessory pad is not permissable. Geiser *et al* (1) discussed the operation and advantages of a hydraulic system for operating dispersal equipment and listed the essential parts required.

Materials and Methods

The investigations reported here were concerned with the installation problems involved in equipping a light plane with a hydraulic system for driving the solution pump. Installation was made on a 1953 PA-18A having a 135 horsepower Lycoming engine with complete electrical system. Hydraulic pump and motor were surplus Vickers units having .610 cubic inch displacement per revolution. Several smaller sizes are available. Displacement is determined by the angle between the pump shaft and the cylinder block. Pumps with a greater angle have a longer stroke which in turn results in greater pump displacement. The relationship between angle and displacement can best be shown in this example:

Pump angle, in degrees	10	15	40	25	30
Displacement cu. in. per stroke	.210	.310	.410	.507	.610

Where high volume spray equipment is installed which includes a large capacity spray pump, a 25° or 30° angle hydraulic pump should be used. The 30° or .610 hydraulic pump is capable of developing up to 7 horsepower depending upon the speed of operation.

Since gear teeth on the accessory pad of the smaller aircraft engines are not designed to handle the horsepower load of a .610 hydraulic pump, it was necessary to design other means of driving the hydraulic pump. The aircraft was equipped with a complete electrical system which included a V-belt pully assembly on the engine crankshaft and on the generator. It had been decided that a V-belt was the most desirable method for driving the hydraulic pump because of its simplicity and greater safety in the event of a pump malfunction. The generator could have been removed and the hydraulic pump mounted on the same mounting brackets. This would have meant starting the engine by hand and doing without the safety afforded by navigation lights during early morning and late evening flights. The generator was retained and a second pulley was put on the generator shaft. This pulley was in turn belted to drive the hydraulic pump. The "cross-over" exhaust system and muffler were removed and two short "Y" stacks carried exhaust fumes straight out the side of the engine cowling. The removal of the weight of the Piper exhaust system and muffler almost completely compensated for the added weight of the hydraulic pump, additional pulley and hydraulic lines. Fire-resistant, flexible hydraulic hose was used from the hydraulic pump back through the fire wall. The hydraulic fluid reservoir and the expansion cylinder were mounted inside the cockpit, behind the fire wall, along the right side of the fuselage. A removable plate was installed in the fuselage fabric to enable checking the fluid level and adding additional fluid when needed. The hydraulic pressure gauge was also mounted on the right side of the fuselage just below the instrument panel. The pressure relief valve, and pressure regulator (needle valve) were connected into a manifold mounted on the floor between the cockpit seat supports and the fuselage wall. An "on-off" valve was mounted on the fuselage floor just below the front edge of the pilot's seat. The pressure line and the return line were carried back beneath the spray tank to the hydraulic motor in the baggage compartment.

The hydraulic motor was connected directly on the shaft of the solution pump using a splined sleeve in the hydraulic motor and a splined shaft on the pump. It was necessary to have this modification performed by the pump manufacturer because it involved shortening the pump shaft and installing a different front bearing and mounting bracket. The complete unit was mounted in the floor of the baggage compartment so none of the spray solution lines actually entered the baggage compartment.

Results and Discussion

The versatility of a hydraulic system for driving the spray pump was immediately apparent on the first work undertaken with the new unit. Spraying amine 2,4-D in one gallon of water per acre resulted in troublesome foaming due to the great excess of solution that was being by-passed back into the tank. With a conventional fan drive nothing could have been done except stop and locate a smaller fan or else continue to operate even though output was very erratic due to air in the pump and spray lines. With a hydraulic drive it was possible to drop the hydraulic motor pressure from 800 to 300 pounds per square inch. Thus slowing the solution pump so less fluid was by-passed. The same spraying pressure was maintained by closing the by-pass globe valve and then cracking it open only ¼ turn. Foaming was completely eliminated and a considerable saving in horsepower was realized by operating at the lower hydraulic pressure.

Hydraulic pressure was found to be remarkably constant with changing engine rpm. A static hydraulic pressure of 700 lbs./sq. in. was maintained throughout a range of 250 engine rpm. Flights were made at varying airspeeds and again no change in hydraulic pressure was observed (table 1).

Table 1. Effect of engine rpm and airspeed on hydraulic pressure.

Hydraulic pressure	Airspeed	Flaps	Engine rpm.
700 psi.	90 mph.	none	2350
700 psi.	65 mph.	none	.....
700 psi.	60 mph.	1 notch	.....
700 psi.	45 mph.	2 notches	2100

Numerous test runs were made over a marked calibration course in order to secure data for each gallonage and nozzle size to be used. These data (table 2 and table 3) show lower horsepower requirements using the body 5 cap 5 nozzles at most of the pressure settings compared to the larger nozzles. This is indicated by the greater difference between static and working hydraulic pressures when using the larger nozzles.

Static hydraulic pressure refers to pressure in the hydraulic system when the hydraulic motor and solution pump are not operating. Working hydraulic pressure indicates the pressure in the hydraulic system when the hydraulic motor is on and the solution pump is working at the indicated boom pressure.

Table 2. Calibration of hydraulic pressure and spray output on a Piper PA-18A using 44 S.S. #4666 body 10 cap 10 nozzles.

Hydraulic pressure (psi)		Boom pressure	Spray output
Static	Working	(psi)	gals/acre
800	1200	28	10.0
700	1100	25	9.5
600	850	21	9.0
500	750	16	7.9
400	600	13	6.9
300	400	10	5.0

Note especially the direct increase in boom pressure with each 100 pound increase in static hydraulic pressure (table 3).

XUM

Table 3. Calibration of hydraulic pressure and spray output on a Piper PA-18A using 44 S.S. #4666 body 5 cap 5 nozzles.

Hydraulic pressure		Boom pressure	Spray output
Static	Working	(psi)	gals/acre
700	1050	40	6.6
600	800	32	6.0
500	650	26	5.0
400	500	20	4.8
300	375	14	4.6
200	300	8	2.7

In all of the calibration runs, the by-pass valve was closed on the spray installation so the output figures in the tables represent total capacity.

Summary

A hydraulic drive was found to be much more versatile as a source of power to operate a spray pump than the widely used fan drive. Hydraulic pressure remained constant while engine speed was varied as much as 250 rpm. and while airspeed was varied from 90 down to 45 mph. A wide range of spray pressures and output gallonages can easily be obtained with the same set of nozzles simply by changing hydraulic pressure. By choosing the lowest pressure and gallonage needed for each spraying operation a minimum horsepower load can be placed on the aircraft engine.

Literature Cited

(1) Geiser, Arthur; Donald Whittam, and Kenneth Messenger. Hydraulic Drive System for Operating Dispersal Equipment in Agricultural Aircraft. U.S.D.A., A.R.S. Plant Pest Control Branch A.R.S.-81-2. August 1955.

(2) Hedden, O. K. Aerial-Spray Equipment for a Piper Cub J-3 Airplane. U. S. Bureau Ent. & Plant Quarantine Information Series No. 88. August 1948.

(3) Husman, C. N., O. M. Longcoy, and H. S. Hensley. Equipment for Dispersal of DDT Insecticides by Means of Aircraft. U. S. Bur. Ent. and Plant Quarantine E. T.-228.

(4) Isler, D. A. Aerial-Spray Equipment for a Stearman N2S Airplane. U. S. Bureau of Ent. & Plant Quarantine. Information Series No. 87. August 1948.

(5) Young, V. D. Pest and Plant Disease Control Machinery Report of the Agricultural Aviation Research Conference. U.S.D.A. and Texas A. & M. Cooperating. College Station, Texas. Febr. 1953.

[1] Published with the approval of the Director as Paper No. 750 Journal Series, Nebraska Agricultural Experiment Station.
[2] Assistant Agronomist, University of Nebraska, Lincoln, Nebraska.

EFFECT OF PESTICIDES ON SPRAY EQUIPMENT

Donald T. Black[1]

Abstract

The problems of corrosion and abrasion occurring in pesticide application equipment have existed since pesticides were first applied. With the recent introduction of many new pesticides, these problems have become progressively more serious. Application equipment has frequently been rendered inoperative or made less effective in performance.

Cooperative work with pesticide and application equipment manufacturers and equipment operators has been undertaken to help reduce these problems. Study has been directed on three lines of approach: (1) use of more resistant construction materials, (2) improvement of pesticide materials and formulations, and (3) proper use and care of equipment to increase its service life.

A survey of the equipment field has shown the spray tank as the most common source of trouble and following in descending order of importance are the hose, pump, nozzle, boom, valve, and screens. Factors contributing to the tank problem include lack of care and maintenance, faulty design preventing adequate cleaning, use of unprotected mild steel for construction. and the corrosive potentials of the pesticides used. Because mild steel is the most common tank construction material due to reasons of economy and design, considerable laboratory and field evaluations for suitable protective coatings have been conducted. Of the great number of recently introduced protective coating materials, only the heat cured phenolic and epoxy type resins have offered promise for handling a majority of pesticides. Results of test work on tank construction materials against a wide variety of pesticides are generalized as follows: (1) 18-8 grades of stainless steel offer superior resistance to a majority of pesticides, (2) zinc has shown a sufficiently high corrosion rate to indicate that galvanized sheet would lose its coating in 2 years or less, (3) low alloy steels have not offered any significant improvement over carbon steel, and (4) aluminum has shown fair resistance generally although it has been subject to pitting and complete perforation with certain materials.

Recently introduced plastics of the reinforced type have offered resistance comparable with stainless steel and are now finding their way into the equipment field. For use in other components of the sprayer, tests have shown Ni-Resist and certain types of bronze to have reasonably good resistance, consistently several times better than cast iron. Copper, yellow brass, and red brass have shown significant corrosion rates and should not be employed where dimensions are critical.

As with protective coatings for tanks, the problems of rubber hose, gasket and diaphragm deterioration became quite serious after the introduction of pesticide formulations containing solvents. This problem has been substantially minimized through use of synthetic rubber or plastic compounds such at Neoprene, Buna N, Thiokol, and Teflon.

The use of ceramic materials for pump cylinders and nozzle orifices has increased, resulting in decreased wear and corrosion at those points. Tungsten carbide steel is also being used in nozzles while chromium-cobalt tungsten alloys are being used for valves and valve seats.

The effect pesticides have on application equipment are being realized by the pesticide manufacturers. Where a pesticide is known to seriously affect common construction materials, work has been undertaken by the manufacturer for determining possible corrosion inhibitors or stabilizers for preventing chemical breakdown. The inhibition of the effect of sodium TCA on aluminum by the addition of sodium dichromate is an example of progress made.

It is generally agreed that a great deal of the damage due to corrosion occurs when application equipment lies idle and uncleaned. Equipment operators are gradually becoming aware of this problem and are attempting to clean their equipment when possible. Sprayer design has prevented proper cleaning in certain instances but progress is being made by manufacturers to improve ease of maintenance. Correct operating procedures as outlined in equipment manuals cannot be stressed too highly. Caution must also be exercised in the selection of the water source for spray mixtures. Water containing sand or other foreign matter can cause serious erosion of pumps and nozzles or be a source of plugged screens and nozzles. Calibration of spray nozzles should be performed frequently.

[1] Agricultural Engineering Research Branch A.R.S. U.S.D.A., Toledo, Ohio.

XUM

LABORATORY APPARATUS FOR STUDYING THE DESIGN AND PERFORMANCE OF THE ROTARY HOE[1]

L. A. Liljedahl[2] and John Strait[3]

Tractor cultivation has been and continues to be a principal weed control measure used in the growing of corn and soybeans in rows. When used as the sole weed control measure, it accounts for about 30 per cent of the horsepower-hours and 50 to 60 per cent of the man-hours required for growing corn and soybeans. Under certain conditions, pre-emergence sprays applied to corn may eliminate the need for the first cultivation, but with both crops there remains a considerable amount of work to be done later in the season when time is at a premium. Research to increase the speed and effectiveness of mechanical cultivation, therefore, is still important.

The rotary hoe is widely used in certain areas of the corn belt for cultivating corn and soybeans up to the time the crop has attained a height of about six inches. The rotary hoe operating at a high ground speed can cover a large acreage per day and its use may be substituted for the tedious and time-consuming first cultivation of small corn and soybean plants with the conventional tractor cultivator.

In Minnesota, the rotary hoe has not been used as extensively as it has in other sections of the corn and soybean-growing area. Farmer acceptance of the rotary hoe has been quite varied and it appears that its effectiveness is dependent to some extent upon the design of the implement.

The Agricultural Engineering Department of the University of Minnesota in cooperation with the United States Department of Agriculture has initiated a project to study the design and use of the rotary hoe. The principal objective of the project is to study design factors and management considerations which influence the effectiveness of the hoe as a weed control and tillage implement. Both laboratory and field studies are in progress.

In order to control variations in test conditions due to the weather and soil variations, we have designed and built the laboratory apparatus described in this paper. The apparatus consists of a stationary stand and tool bar upon which is mounted the rotary hoe wheels under study; a box 15 feet long, 5 feet wide and 8 inches deep containing a bed of soil and mounted on a low-wheeled car; and a suitable drive unit which moves the bed of soil past the tool bar enabling the hoe wheels to work in the soil as they would in the field. The tool bar on which the rotary hoe wheels are mounted is fully adjustable both laterally and vertically so that the hoe may work at any desired depth and at any position in the soil bed. The car for carrying the box of soil has V-grooved, cast-iron wheels which run on an angle-iron track. Other boxes containing different soil types may be placed on the car. The box of soil is moved at a predetermined rate by a 15-hp electric motor operating through a suitable power transmission system which transmits the driving force through a sprocket to a roller chain attached to the soil car. The car may be moved under the test section at any speed between one and eight miles per hour. A high-speed motion picture camera is used to photograph the action of the hoe teeth working in the soil during the test run.

Detailed procedures for evaluating the performance of the rotary hoe wheels in any particular test have not been completely worked out. The high-speed motion picture camera will be used as one means of evaluating performance. The high-speed camera is capable of taking pictures at from 1000 to 3000 frames per second. Pictures taken at 3000 frames per second, when projected at the standard 16 frames per second rate, enables one to view the action at about 1/200th of its original speed. Individual frames will also be used for evaluation purposes.

The general procedure will be to study the performance of several wheels of different designs in a limited number of soil types and under different conditions of the soil bed in an attempt to discover design characteristics of the hoe wheel which contribute to good performance. Performance criteria which may be used would include percentage of the total surface disturbed; the degree of pulverization of the surface layer; the penetration and variation in penetration obtained with a given force tending to cause the wheel to penetrate; and the action of the hoe wheel on growing plants. It is believed that after we evaluate the performance of several wheel designs using the above criteria, we will be able to determine wheel design factors which influence their performance. These design factors would be the cross-sectional shape and curvature of the teeth; the number of teeth per wheel; the diameter of the wheel; and the speed of operation. As a result of these studies we may be able to design a better tooth shape and wheel which will give more consistent and satisfactory performance with the soil conditions and weed populations prevalent in Minnesota.

We expect that the equipment described in this paper will be very useful in studying tillage mechanisms other than the rotary hoe. The use of the high-speed camera would enable one to follow soil movement, pulverization, and action on the plant resulting from the use of any cultivating mechanism.

---

[1] Approved as Scientific Journal Series Paper No. 3472. Minnesota Agricultural Experiment Station, St. Paul, Minnesota.
[2] Agricultural Engineering Research Branch, U.S.D.A.
[3] Associate Professor of Agricultural Engineering, University of Minnesota.

THE EFFECT OF SEVERAL CHEMICALS APPLIED IN THE FALL FOR THE CONTROL OF WILD OATS

George Friesen[1]

From October 6 to November 9, 1954, eight experiments were laid out on farm fields at widely scattered points in Manitoba, to compare the effectiveness of several herbicides for the control of wild oats. The chemicals used were IPC (3 rates), CIPC (1 rate), TCA (3 rates), Dalapon (1 rate), 2,4-D (4 rates) and 3,4-D (1 rate at only 1 location). All chemicals were applied as a liquid spray. (10 gals. total volume per acre.) Possible effects of trash and after treatment cultivations were also compared. The wild oat content of these fields varied from 735 to 6842 seeds per square yard in the top one inch of soil (2¼ to 21 bus. per acre.)

The effects of these treatments on wild oats and on cereal crops seeded in 1955 are shown in Tables I and II, and can be summarized as follows:

IPC—at least 10 pounds per acre were necessary to give satisfactory wild oat control. Only at two locations was there residual toxicity at time of seeding cereals.

CIPC—gave better wild oat control than IPC at comparable rates, but there was slightly longer residual toxicity. The poor control of wild oats with IPC and CIPC at Morden and East Selkirk was attributed to a heavy trash cover and poor incorporation respectively.

TCA—at rates of 20 and 30 pounds per acre gave excellent control or suppression of wild oats. At 10 pounds per acre control was only fair. However no crops could be grown in 1955 because of residual toxicity of the chemical. There were also indications that TCA only suppressed or delayed the germination of wild oats, that is, as soon as the chemical was leached from the soil, wild oats grew normally.

Dalapon—the results with this chemical were somewhat erratic.

2,4-D—at rates used was ineffective in controlling wild oats. Unfortunately 3,4-D was used at only one location, but results indicate that it warrants further testing.

After treatment cultivation. With IPC immediate and thorough soil incorporation was essential. With CIPC incorporation was also essential but timing was not as critical. A heavy trash cover was found undesirable where IPC and CIPC were applied, since it interfered with the incorporation process. There seemed to be no benefit from packing the soil following the incorporation of the chemicals. Other chemicals gave similar control whether worked into the soil or not.

TABLE I.

Per Cent Reduction of Wild Oats, Spring of 1955, Visual Estimates in Most Cases.

Treatment	Average of six locations*
IPC—5 lb/ac	20
IPC—10 lb/ac	41
IPC—15 lb/ac	60
CIPC—10 lb/ac	66
TCA—10 lb/ac	68
TCA—20 lb/ac	86
TCA—30 lb/ac	94
Dalapon 10 lb/ac	48
2,4-D-E 15 lb/ac	7
3,4-D 4 lb/ac	90

* No wild oat emergence at other two locations. Data for only the highest rate of 2,4-D (15 lb/ac) are presented. Low average readings for ICP and CIPC are accounted for by complete ineffectiveness at 2 locations because no soil incorporation possible.

TABLE II.

Extent of Damage to Wheat and Barley Seeded in 1955.

Treatment	Damage
IPC—5 lb/ac	nil
IPC—10 lb/ac	nil
IPC—15 lb/ac	nil to thinned
CIPC—10 lb/ac	nil to thinned
TCA—10 lb/ac	nil to killed
TCA—20 lb/ac	killed
TCA—30 lb/ac	killed
Dalapon 10 lb/ac	nil to killed
2,4-D-E 15 lb/ac	nil
3,4-D 4 lb/ac	nil

Flax was seeded at Morden Exp. Sta. and Gilbert Plains. At Morden it was seriously damaged by 3,4-D and all rates of TCA. At Gilbert Plains flax did not show damage from any treatment.

The Experiment at The University of Manitoba.

The experiment at the University included only one chemical, IPC. This was applied at three rates (4, 8 and 12 lbs/ac) and at three dates (October 8, October 22 and November 4). In one half of the experiment the wild oat seed was left in the soil surface, while in the other half the wild oat seed was incorporated into the top 2-3" of soil. No crops were planted in the spring of 1955.

Wild oat control in 1955 was similar where the seed had been left on the surface or incorporated into the soil prior to treatment.

At 4 pounds per acre IPC did not control wild oats. Where 8 pounds per acre were applied, only the last date of application gave good control of wild oats, the earlier 2 dates giving virtually no control. The rate of 12 lbs/ac was high enough to give satisfactory control of wild oats regardless of the date applied.

The following table shows the number of wild oat culms per square yard in the various plots (counts made July 15.)

	Date of Application	Culms per square yard: Wild oat counts in treated plot	Wild oat counts in adjoining check
IPC— 4 lbs/ac	Oct. 8	511	423
	Oct. 22	369	416
	Nov. 4	483	585
IPC— 8 lbs/ac	Oct. 8	385	400
	Oct. 22	319	378
	Nov. 4	25*	369
IPC—12 lbs/ac	Oct. 8	17*	315
	Oct. 22	14*	405
	Nov. 4	12*	261

* Due to extensive tillering these counts represent only a few plants.

1 Division of Plant Science, The University of Manitoba, Winnipeg, Manitoba.

MCP vs 2,4-D FOR THE CONTROL OF WEEDS IN GRAIN CROPS

H. A. Friesen[1]

The question of 2,4-D or MCP assumes major proportion in Western Canada, where, of the 40 million acres devoted to cereal grains, an estimated 12 million acres annually have been sprayed for the control of weeds. During the five years immediately following the introduction of 2,4-D into the prairie provinces, in 1945, the research program was almost entirely devoted to studying the effect of 2,4-D on weed and crop species. These studies showed that wheat and barley possessed a much greater tolerance to 2,4-D than oats and flax, notably in the earlier growth stages. It has also been pointed out by a number of workers in Canada, the United States and Europe that cereals and flax were more tolerant to MCP than they were to 2,4-D treatments. This, coupled with the rather frequent reports of injury to oats and flax on the farm, prompted, seven Experimental Farms in Western Canada, in 1954, to embark on a more or less "uniform" project to establish the status of MCP in the weed control program.

The main phase of this project involved the testing of an ester, an amine and a sodium salt formulation of MCP and an amine, an ester and a low volatile ester formulation of 2,4-D on annual weeds in oats and flax. Each formulation was applied at two stages of weed growth, namely 1) the seedling stage when the weeds were 2 to 3 inches tall and 2) the bud stage. Each formulation was applied at 4 and 8 ounces per acre. The effectiveness of each treatment on the weeds was assessed by plant counts before and after spraying and by the dry weight of the weeds taken at heading or flowering time of the crop. The effect on the crop was assessed by yields and observations on morphological characteristics. The major weed species common to all test locations were stinkweed, *Thlaspi arvense*, lambs' quarters, *Chenopodium album*, Russian pigweed, *Axyris amarantoides*, and wild mustard, *Brassica arvensis*. Hemp nettle, *Galeopsis tetrahit*, was prevalent at Lacombe and Regina, while Russian thistle, *Salsola Kali*, was prevalent only at Lethbridge. Four of the tests were conducted with flax as the crop, oats were used at two locations and barley was used at one. For purposes of brevity the dry weight of weeds and yield of crops for all MCP and 2,4-D formulations have been bulked and these are presented in Table I.

The data presented in 1955 would substantiate many of the observations made in previous years on the relative effectiveness of MCP and 2,4-D as weed killers. Each formulation at each rate of application gave highly satisfactory control of stinkweed, wild mustard, Russian pigweed and lambs' quarters. The 2,4-D ester and low volatile ester resulted in equal and satisfactory control of Russian thistle while the 2,4-D amine was only slightly less effective. On the other hand each MCP

XUM

formulation was very much inferior to each of the 2,4-D forms. The MCP formulations, notably the ester, killed some 30 per cent of the hemp nettle plants and suppressed the growth of the survivors to less than 30 per cent of normal. The 8 oz./A. rate was significantly more effective than the 4 oz./A. rate. None of the 2,4-D treatments resulted in more than a very temporary set-back of the nettles. Wild buckwheat, while not present in appreciable proportions in 1955, was neither killed nor effectively controlled by any of the treatments. However, the low volatile ester and the ester of 2,4-D did result in some suppression of this weed. Each of the treatments was more effective when applied during the seedling stage of the weed.

It was of considerable interest to note that a leaf feeding beetle, *Gastrophysa polyoni L.*, removed the buckwheat from the test plots at Scott, Saskatchewan, leaving the grain and other weed species untouched.

The effect of the treatments as measured by the yield of flax and oats tended to show significant differences in favor of the MCP formulations. At each of the four locations reporting on work with flax in 1955 the highest yields following treatments with either MCP or 2,4-D were realized when the treatment was made at the early or seedling stage of the weeds. At Regina, Morden and Brandon the weed species encountered were equally susceptible to MCP and 2,4-D. Under these conditions the MCP plots gave consistently higher yields of flax than the 2,4-D plots. However, the differences were not large. At the later date of spraying the yield differences again favored MCP but by a wide margin. The Lethbridge trial in 1955 was of interest in that Russian thistle was the major weed species. In this trial the 2,4-D amine and ester resulted in the highest yields at the early treatment date, while at the late stage only the MCP ester at the heaviest rate increased the yield. As stated earlier, the control of Russian thistle at each growth stage by MCP was much inferior to that achieved by the 2,4-D formulations. In all trials the low volatile ester of 2,4-D was the most deterimental to the yield of flax, this effect was especially pronounced at the higher rate and the later stage of treatment.

A further significant observation was the differential effect of these herbicides on date of maturity of the flax. The 2,4-D ester and low volatile ester treated plots required four to eleven more days to mature than did the MCP treated plots. The untreated plots matured one to two days earlier than those treated with MCP. This factor is of great importance because of our rather short frost free seasons. Thus, when this trial was run at Melfort, Saskatchewan, in 1954, the untreated flax contained 30 per cent frozen seed, the MCP treated flax 40 per cent and the 2,4-D treated flax contained over 65 per cent of frozen seed. The effect of this frost on the yield and grade of the flax should require no further explanation.

The effect of MCP and 2,4-D on the yield of oats, as with flax favored the former compound. At Scott, under the essentially weed free condition due to the removal of the wild buckwheat by beetles, the 2,4-D treatments significantly reduced the yield of oats at the early date of spraying. The 2,4-D treatments at the late date and the MCP at both dates of spraying did not influence the yield of oats significantly. At Lacombe the oat plots were heavily infested with hemp nettle and stinkweed. Each treatment resulted in complete elimination of the stinkweed. The partial kill and suppression of the hemp nettle by the MCP treatments at 8 oz/A applied at the early date of spraying increased the yield of oats. The 2,4-D treatments at this date not only failed to suppress the nettles but also injured the oats with the result that highly significant yield reductions were sustained. At the late stage of treatment the more prolonged competition of both the hemp nettle and the stinkweed reduced the yield following each of the treatments. The reduction was significant for all treatments except the MCP at 8 oz./A. The effect of these treatments on date of maturity was not sufficient to be of any consequence.

The data accumulated in these and in other earlier trials would favor the use of MCP for the control of annual weeds in flax, since an increase of only one-half bushel per acre is sufficent to justify the extra cost. Furthermore, the hazard of delayed maturity is largely overcome by the use of this herbicide. Where the major weed species is decidely more susceptible to 2,4-D as is Russian thistle, the increase in yield due to the removal of the weed competition by 2,4-D will often more than offset the injury to the crop.

The work with oats, as with flax, favored the use of MCP over 2,4-D. This crop was found to be decidedly more tolerant to MCP at the early growth stages, in other words, at the time when weed competition is most critical. The additional cost of MCP will be more than offset by the improved yields as the result of early spraying. 2,4-D amine and ester formulations may be used to advantage where the predominant weed species cannot be controlled by MCP but is readily controlled by the former.

As stated earlier in this paper and supported by the 1955 results with barley at Melfort this year, the yield of wheat or barley treated at the 4 to 6 leaf stage has not been adversely affected by MCP or 2,4-D formulations applied at recommended rates. Because of its lower cost, 2,4-D would then be the preferred material. MCP could be used to advantage under the following three conditions: 1) the major weed species to be controlled was less susceptible to 2,4-D; 2) the weed growth dictated the need for treating before these crops had reached the four leaf stage of growth; and 3) the crops were undersown with legumes.

TABLE I.

Dry Weight of Weeds and Yield of Grain Following Various MCP and 2,4-D Treatments—1955.

	Flax						Oats		Barley
	Regina				Swift				Mel-
	1	2	Morden		Current		Lacombe	Scott	fort
Treatment	Wds.	Yld.	Wds.	Yld.	Wds.	Yld.	Wds.	Yld.	Yld.	Yld.
Date 1										
MCP 4oz/A	777	11.3	43.8	17.7	90.8	21.7	872	63.2	86.6	42.5
MCP 8oz/A	777	12.4	26.3	16.8	111.7	25.9	458	65.0	84.6	42.8
2,4-D 4oz/A	647	11.5	25.0	15.2	262.5	20.8	866	49.5	70.1	40.4
2,4-D 8oz/A	667	10.5	13.0	16.3	35.8	21.0	1064	43.5	69.3	41.4
Date 2										
MCP 4oz/A	837	7.5	721.0	16.3	247.5	20.9	808	54.9	81.9	39.8
MCP 8oz/A	1135	7.4	525.3	15.5	252.5	22.2	656	64.2	80.8	41.1
2,4-D 4oz/A	855	6.7	662.0	12.2	262.5	20.7	968	41.2	81.0	41.0
2,4-D 8oz/A	728	5.4	517.5	10.2	113.3	18.6	898	38.7	77.8	39.8
Check	1175	9.6	989.0	14.3	332.5	22.5	2280	63.8	79.4	39.5

1 Dry weight of weeds in lbs/A—taken at the late flower stage of the untreated weeds.
2 Yield of crop in bushels per acre.

1 Experimental Farm, Lacombe, Alberta.

THE EFFECT OF ISOOCTYL ESTER OF 2,4-D ON EIGHT VARIETIES OF OATS[1]

Paul F. Sand and N. E. Shafer[2]

Introduction

Varietal difference in response to 2,4-D has been demonstrated in corn, oats, flax, barley, and sorghum. Dunham (1) reports that a tolerant variety of flax has been uninjured from an application of four times the amount of 2,4-D that reduced the yield of a susceptible variety. Ahlgren, Klingman and Wolf (2) point out that varieties of small grain vary considerably in their resistance to 2,4-D; therefore susceptibility must be determined for each small grain variety.

The purpose of this experiment was to test some of the oat varieties grown in Nebraska for susceptibility to 2,4-D. The oats were sprayed at what is considered to be a susceptible stage of growth, the joint stage, and a stage when they become more tolerant to 2,4-D, the boot stage. To bring out possible differences in varieties, a recommended rate of 2,4-D, one-fourth pound per acre,

and a heavier rate of one pound per acre were applied at these two stages of growth.

Materials and Methods

Eight varieties of oats were sprayed with the isooctyl ester of 2,4-D at two stages of growth for three successive years, 1953, 1954 and 1955, at Lincoln, Nebraska. The oat varieties consisted of six recent varieties, Nemaha, Andrew, Marion, Ajax, Mo. 0-205, and Clinton, and two older varieties, Kherson and Kanota.

The experimental design used was a split plot with rates and stages as main plots and varieties as subplots. Each variety was planted in plots consisting of five rows, one foot apart, and fourteen feet long. The plants were considered to be in the joint stage when the head was one to three inches above the ground. The heads were well in the boot before spraying was done for the boot stage. All varieties were not sprayed on the same date, but the stage of growth was checked carefully for each, and sprayed when it most nearly approached the desired stage. Two rows, eight feet long, were harvested for yield tests from each plot.

Fertilizer was applied in 1954 at the rate of 40 pounds of nitrogen per acre.

Weather conditions varied considerably during the three years. In 1953, the rainfall in April was above normal but May and June were dry with less than half the amount of normal rainfall. The moisture received in 1954 during April, May and June was near normal or above the precipitation in April, and May of 1955 was below normal, while June was somewhat above normal.

Results and Discussion

Not all varieties responded the same every year. Data in table 1 show that in 1953 yields of four varieties, Nemaha, Clinton, Kanota, and Mo. 0-205, were reduced significantly from the check by one pound of 2,4-D in the joint stage. No other reductions in yields were obtained in the 1953 season. In 1954, yields (table 2) were much higher and chemicals had more effect on the oats. Yields of all varieties except Mo. 0-205, were reduced significantly from the check by one pound per acre of 2,4-D in the joint and boot stages; and yields of Marion and Clinton were reduced significantly by one-fourth pound per acre of 2,4-D at the joint stage.

Data presented in table 3 show that in 1955 the yields of five varieties were reduced significantly from the check by the one pound per acre rate in the joint stage. They were Nemaha, Ajax, Marion, Clinton, and Kanota. The yield of Marion was reduced significantly in the joint stage at one-fourth pound of 2,4-D per acre. Although the yields in 1955 are about the same as those in 1954, the treatments did not have nearly as much effect on the oats. This could have been due to the fact that growing conditions in 1954 were ideal at the time of spraying making the oats more susceptible to the treatments. In 1955 soil moisture was extremely short at the time of treatment. The oats were not growing as actively and therefore were not affected as much by the treatments as they were in 1954. However, in 1955 after the treatments were applied in May, early June rains produced good oat yields.

Table 1. Average yields in bushels per acre of eight varieties of oats treated at two stages of growth (joint and boot) at one pound and one-fourth pound per acre of isooctyl ester of 2,4-D. 1953. Average of four replications.

	Joint Stage			Boot Stage		
Variety	1 lb.	¼ lb.	Ck.	1 lb.	¼ lb.	Ck.
Nemaha	14.7**	17.4	20.1	16.8	20.5	19.5
Kherson	16.7	19.9	17.1	16.5	18.9	17.3
Ajax	22.5	21.8	18.6	18.9	20.3	19.1
Andrew	27.1	31.2	30.6	26.5	29.2	29.4
Marion	24.4	26.0	27.0	23.5	26.1	24.1
Clinton	14.5**	19.0	21.1	16.4	19.9	20.1
Kanota	24.3**	27.6	31.5	26.7	27.4	26.6
Mo. 0-205	26.2*	33.1	30.5	30.7	30.9	26.0
Average of all varieties	21.2	24.2	24.6	21.9	24.1	22.7

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.

Table 2. Average yields in bushels per acre of eight varieties of oats treated at two stages of growth (joint and boot) at one pound and one-fourth pound per acre of isooctyl ester of 2,4-D. 1954. Average of four replications.

	Joint Stage			Boot Stage		
Variety	1 lb.	¼ lb.	Ck.	1 lb.	¼ lb.	Ck.
Nemaha	18.0**	45.4	48.2	33.8**	49.1	49.9
Kherson	26.3**	49.7	45.0	31.8**	45.3**	54.0
Ajax	38.7*	49.9	45.4	41.4**	50.6	49.1
Andrew	39.5**	58.5	58.2	45.2**	56.8	57.2
Marion	25.8**	36.0**	44.7	20.1**	35.1	39.8
Clinton	38.4**	43.6**	52.0	39.1**	41.8**	53.1
Kanota	30.4**	52.0	50.3	46.0*	55.5	51.7
Mo. 0-205	58.0	68.2	63.5	59.9	55.9	59.3
Average of all varieties	34.4	50.4	50.9	39.7	48.9	51.8

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.

Table 3. Acreage yields in bushels per acre of eight varieties of oats treated at two stages of growth (joint and boot) at one pound and one-fourth pound per acre of isooctyl ester of 2,4-D. 1955. Average of four replications.

	Joint Stage			Boot Stage		
Variety	1 lb.	¼ lb.	Ck.	1 lb.	¼ lb.	Ck.
Nemaha	27.8**	41.7	46.5	36.9	41.1	42.7
Kherson	52.1	63.3	57.1	62.2	60.5	59.8
Ajax	57.5**	71.1	74.8	65.8	72.6	70.2
Andrew	52.8	64.4	58.1	58.0	60.9	57.7
Marion	56.5*	56.5*	68.1	60.4	69.3	68.4
Clinton	33.6**	57.2	49.6	46.9	50.2	54.1
Kanota	27.2**	46.9	54.2	36.5*	47.0	47.1
Mo. 0-205	64.8	68.9	65.5	67.6	68.2	66.2
Average of all varieties	46.5	58.7	59.2	54.3	58.7	58.3

* Significantly different from the check at the 5% level.
** Significantly different from the check at the 1% level.

Summary

1. Mo. 0-205 shows more tolerance to the isooctyl ester of 2,4-D than other varieties. Yields of this variety were not affected by treatments in 1954 or 1955.

2. Nemaha, Clinton, and Kanota were affected by the one pound per acre rate in the joint stage every year.

3. Although Marion was unaffected in 1953, its yield was reduced by both the one pound and one-fourth pound per acre rate in the joint stage in 1954 and 1955.

Literature Cited

1. Dunham, R. S. Screening Breeding Stocks for Herbicidal Tolerance. Proceedings Tenth Annual Meeting of the North Central Weed Control Conference. Dec. 1953.

2. Ahlgren, G. H., G. C. Klingman, and Dale E. Wolf. Principles of Weed Control. 1951. John Wiley and Sons, Inc.

[1] Published with the approval of the Director as Paper No. 747, Journal Series, Nebraska Agricultural Experiment Station.

[2] Assistant in Agronomy and Assistant Agronomist, respectively, University of Nebraska, Lincoln, Nebraska.

THE EFFECT OF WILD MUSTARD REMOVAL BY MCP OR 2,4-D AT VARIOUS STAGES OF GROWTH OF WHEAT, OATS OR BARLEY

L. H. Shebeski[1]

As early as 1935 a survey made in Western Canada revealed that typical fields averaged about 20,000 viable weed seeds in the top inch of one square yard of soil. The predominant weed in the Red River Valley at that time was wild mustard. With the advent of 2,4-D and MCP, farmers had a means of reducing the weed seed content of the soils. This spring a survey was made

XUM

of the number of broad-leaved weeds growing in farmers' fields in Manitoba when grain was approximately in the 3-leaf stage. In wheat on summerfallow an average of 285 weeds were found per square yard and in barley on stubble an average of 385 weeds were found per square yard. Most of the fields at the time of the survey appeared quite clean from the highway.

Effect of wild mustard removal will be dealt with strictly in relation to yield of grain. The first point that must be established is the degree of weed infestation required to reduce yield of grain. Experiments were designed wherein flax, wheat, oats or barley were grown alone or in association with 10, 25, 50, 100, 200 or 400 mustard plants per square yard. One half of each plot was sprayed to demonstrate the effectiveness of weed removal by chemical. With flax as few as 10 mustard plants per square yard in two successive years were sufficient to reduce yield by 60 per cent. With wheat or barley at least 50 mustard plants were required before yield reductions were measurable. With oats, 25 mustard plants gave significant reductions in yield.

In 1952 wheat was sprayed at the 5-leaf stage using an ester formulation at 6 oz. acid equivalent per acre. In 1953 wheat was sprayed at the early 4-leaf stage using 4 oz. of ester per acre. Some of the pertinent yield results are presented in Table I.

TABLE I.

Effect of Mustard Competition and 2,4-D Treatment on Wheat Yields.

Mustard plants per square yard	Bushels per Acre Treated	Untreated
1952		
0	40.7	36.5
25	37.1	37.0
50	35.3	32.2
100	28.7	29.2
1953		
0	22.5	22.9
50	22.6	18.4
100	23.2	15.7
200	22.4	13.4

Although mustard control was excellent in both years, apparently the full competitive effect of mustard was expressed even before wheat reached the 5-leaf stage in 1952. The only value of spraying was in the prevention of seed set of mustard. In 1953, spraying was sufficiently timely to really pay dividends.

In 1954 experiments were designed to obtain more information on when in the growth of wheat, oats or barley does mustard competition begin to reduce yields. These crops were grown free of mustard and in association with 100 and 200 mustard plants per square yard.

Plots were sprayed at 19, 29 and 35 days after emergence of grain. Data for wheat were presented in last year's proceedings. Results were similar for all 3 crops. The data for the oat experiment are presented as typical of the 3 crops.

TABLE II.

Effect of time of removal of mustard competition on oat yields.

Time of Treatment	Mustard plants per square yard	Bushels per acre
None	0	127.2
	100	71.1
	200	72.6
19 days	0	130.7
	100	123.2
	200	126.2
29 days	0	123.7
	100	110.7
	200	116.3
35 days	0	133.0
	100	70.9
	200	80.9

Effect of mustard competition became noticeable about 29 days after emergence and the full impact of competition was expressed within 6 days.

Evidence to date indicates that the time competition may become effective will vary from year to year, but when weeds begin to take their toll, they do so very quickly. One obvious conclusion—spray early.

The question of time of spraying has taken into consideration the sensitivity of the crop. There has been ample evidence to show that oats is sensitive to 2,4-D under some conditions at about the 4-leaf stage. Therefore, in 1955, the oat experiment was broadened to include five spraying dates and to compare the effect of MCP and 2,4-D on oat yields at each of the spraying dates. Both herbicides were applied at the rate of 4 oz. acid equivalent per acre and ester formulations were used.

Yield reductions were not as great as in the previous year. One hundred mustard plants per square yard reduced the yield of oats by 14 bushels per acre. In the mustard free plots a far greater reduction in yield was caused by 2,4-D at the 4-leaf stage than was caused by mustard.

Effect of MCP and 2,4-D on weed-free oat yields are presented in Table III.

TABLE III.

Effect of MCP and 2,4-D on weed-free Rodney oat yields at five stages of growth.

Stage at treatment	Bushels per acre MCP	2,4-D
No treatment	83.4	83.4
2-leaf	78.4	68.7
3-leaf	84.1	68.1
4-leaf	78.3	41.5
6-leaf	79.9	67.4
Shot blade	77.2	83.3

The results of this experiment confirm other reports that oats is susceptible to 2,4-D at about the 4-leaf stage but is quite safe to use in the shot-blade stage. However, since weeds usually have done all their damage by that stage, the obvious solution is to recommend the use of MCP rather than 2,4-D for the easier to kill weeds and to recommend spraying at an early stage of growth if weed growth warrants spraying. If harder to kill weeds are known to be present, then crops such as wheat or barley should be used rather than oats.

1 The University of Manitoba, Winnipeg, Manitoba.

LABORATORY AND FIELD STUDIES WITH SEVERAL A-CHLOROACETAMIDES AND CHLORALLYL DITHIOCARBAMATES ON CORN AND SOYBEANS

F. W. Slife[1]

In 1954 several chloroacetamides and dithiocarbamates were tested for their herbicidal activity as preemergence herbicides. In an early field screening test where there was abundant moisture both types of materials gave excellent grass control without injury to corn or bean crops. In a second screening test several weeks later the same results were obtained. The results of these screening tests were so outstanding a detailed field test was laid out in early June of 1954 on both corn and soybeans. The rates used in these tests were 3, 6, and 9 lbs of acid of the diallyl acetamide (CDAA) and the diethyl dithiocarbamate (CDEC). No rain fell after the treatment had been applied and grass weeds emerged on all treated plots. Under these environmental conditions, CDAA was much superior

XUM

to the CDEC. Although the grass weeds emerged on the CDAA plots, they stopped growing when they were 2 inches tall and remained in this condition throughout the season. Rain fell about 6 weeks after treatment, but this did not influence the results with CDEC and the results were extremely poor with this chemical under these conditions.

Laboratory tests were initiated with both compounds to study their residue and leaching properties. CDAA and CDEC were added to Sable Silt loam at 8 lbs per acre and then stored at 40, 60, 80, and 100° F, both in a moist and dry condition. After storage of 2, 4, 6, 8, 10, and 12 weeks, these samples were then tested to determine the amount of residue after the appropriate storage period. The test method used was a bio-assay method of measuring the root restriction on germinating cucumber seeds which had been worked out previously.

This test indicated that under high temperatures and moist conditions both compounds break down completely between 2 and 4 weeks. Under dry conditions, the soil residue extends beyond 4 weeks. Under cool conditions (40° F) there is little breakdown of either chemical in 12 weeks either under dry or moist conditions. This test also indicated that CDEC has slightly longer soil residue under comparable conditions than CDAA.

Both compounds were leached through 3 different soil types. The soil types used in this study were selected on the basis of widely varying characteristics. One was a heavy clay soil, one was a silt loam, and the 3rd was a sand.

CDEC resisted leaching very well in all 3 soil types, even in the sand, and was found mainly in the upper 2 inches of the soil column. CDAA was completely leached out of the sand, moved to a depth of 4 inches in the silt loam, and moved about 2 inches in the heavy clay soil. It would appear that both compounds are adsorbed on clay colloids and organic matter, but even though they are adsorbed, they are still available to germinating weed seeds.

Seeds of soybeans and corn were germinated in solutions of both compounds and in soil treated with both chemicals to determine if these crops had an actual tolerance to the chemicals. The results of this test indicated a tremendous tolerance of corn to both chemicals, and considerable tolerance of soybeans. This test also indicated that CDAA was slightly more toxic to both germinating corn and soybeans than was CDEC.

In 1955 additional field tests were initiated using both CDAA and CDEC on corn and soybeans. The data obtained on weed control indicated that 4 lbs of acid of either material seemed to be the minimum amount necessary to give weed control under varying climatic conditions. No injury was observed or measured in yield when as high as 9 lbs of acid was used on each crop under heavy rainfall conditions.

A considerable number of field demonstrations were observed during the 1955 season and they indicated that CDAA gave better weed control under a variety of environmental conditions than CDEC. These 1955 tests again indicate that good weed control results from CDEC are more dependent on rainfall after application than with CDAA.

In summary, it would appear that these new compounds hold considerable promise for the control of annual grass weeds in corn and soybean crops. Our work indicates that CDAA is less subject to failure than CDEC and that it has begun to eliminate some of the serious weaknesses in previous pre-emergence chemicals, namely, poor results under low rainfall and crop injury under heavy rainfall.

[1] University of Illinois, Urbana, Illinois.

CONTROL OF CERTAIN ANNUAL GRASS WEEDS IN CORN

David W. Staniforth[1]

The successful use of 2,4-D to control many broadleaved weed species in corn has tended to focus attention on the problem of annual grass weed control. These weed infestations are often controlled but not eradicated by the cultural operations followed in corn production. Thus some residual infestation generally survives the cultivation program. These residual infestations may become severe enough to present a potential hazard to corn production whenever cultivation is incomplete or when the weeds become established after cultivation can no longer be carried out. The occurrence of rainfall and wet soil conditions which interfere with the timeliness of early cultivations are among the main factors responsible for the failure of cultivation to control annual grass weeds.

Several promising herbicides have been developed for the control of annual grass weeds in corn. The potential role of such herbicides in corn production appears to lie in the extent to which their use will supplement cultivation by controlling weeds during periods of delay in cultivation occasioned by wet weather. This role may be further narrowed by the fact that in some seasons the cultivation program alone, is sufficient to effect economical if not complete control. Thus only in those seasons in which early season cultivation is impaired by wet weather will the complete potential of herbicides be realized. Many promising grass herbicides have proven most effective under conditions of moderate to even heavy supplies of soil moisture. The dry weather which may contribute to partial failure of herbicides, provides excellent conditions for the control of weeds by the cultivation operations.

Successful utilization of herbicides for annual grass control in corn requires more than the development of a suitably selective herbicide. The herbicide should also be adapted to current methods of corn production, and the cost of its use must not be out of line with the expected economic return resulting from its use. Experiments conducted during the past six years have shown that moderate infestations of yellow foxtail and green foxtail in corn reduced corn yields by 6-8 bushels per acre, or about 10 per cent or less, under good conditions of corn production. These losses were greater with larger weed infestations and on soils low in nitrogen. These figures indicate the economic soundness of using an herbicide which would reduce annual grass weed infestations to a point approximating the weed free condition.

Herbicides at present available and suitable for the control of foxtail in corn may be utilized as pre-emergence or as early post-emergence applications, and to a limited extent as lay-by treatments. Pre-emergence applications are subject to more chances of heavy rainfall which may result in corn injury. Applications of herbicides at very early stages of corn growth appear most promising at the present time. When soil conditions are optimum the application could well be preceded by a shallow cultivation with a rotary hoe or similar equipment. If no sizeable amount of rainfall is encountered during the following two or three weeks, the normal cultivation program can be carried out with good results in weed control. If rainfall and wet weather delays the cultivation operations, the herbicide should control the weed infestation until cultivation can be continued. Such a program could also be expanded to permit some delay in cultivations with a view to eliminating one or more cultivation operations. Under these conditions the herbicide is used as an insurance against cultivation failure, and the cost of the herbicide becomes a sort of insurance premium.

XUM

Among the herbicides tested in this system of herbicides utilization, DNBP, 2,4-D and CMU have been most suited. Of these three, the DNBP is least suitable since it cannot be effectively used until after the foxtail weeds have emerged, and at this time the corn seedlings are often injured appreciably by the herbicide treatment. Treatments with 1 and 2 pounds per acre of 2,4-D amine, applied when corn is between coleoptile stage and 2-3 leaves has given excellent control of foxtail, with little or no injury to the corn. When these 2,4-D treatments were followed by shovel cultivations three or four weeks after corn planting, the degree of weed control approached the weed free condition in most experiments. When dry weather contributed to partial failure of the treatment, the grass weeds were easily controlled by cultivation. The use of 1 or 2 pounds per acre of CMU applied at about the same stage of corn growth has given very good control of foxtail, with little or no corn injury. The residual effect of the CMU was greater than that of 2,4-D amine, and CMU could also be used on larger foxtail seedlings than 2,4-D could, with good kills being obtained. Very limited tests with CDAA have indicated that this material may have some potential when applied at the coleoptile stage of corn growth.

The foregoing statements are based on experiments done in Iowa, under the conditions of weed infestations and soil types found in selected experimental areas. The estimates of weed losses, which in turn determine the economic feasibility of herbicides, are based on specific infestations of green and yellow foxtail, under the conditions of soil fertility and soil moisture encountered in various experimental areas and seasons. Under some of these conditions, the use of herbicides for the control of yellow and green foxtail apparently is economical and practical. The methods of herbicide utilization suggested, seemingly would serve to supplement the present system of cultural control.

1 Iowa State College, Ames, Iowa.

CONTROL OF HAIRY CHESS *Bromus commutatus* Schrad. IN A WARM SEASON GRASS PASTURE[1]

M. K. McCarty and Paul F. Sand[2]

Introduction.

The last decade has seen the science of selective weed control grow to phenomenal proportions, particularly in regard to control of broad-leaved weeds. The most spectacular success has been obtained where dicotyledonous weeds were controlled in plantings of monocotyledonous crops. More recently, this picture has been reversed with chemicals being produced for removing weedy grasses from broad-leaved crops. However, selective control of weedy grasses in grass family crops has been only partially successful to date.

There is a need for methods of controlling weedy grasses in the grass family crops. In the Central Plains area, warm season grass pastures are a valuable segment of the agricultural economy and represent quite an investment in time, labor and money to get established. Cool season annual grasses are serious weeds in these pastures and present a definite weed control problem.

Materials and Methods.

A pasture seeding study was started in the spring of 1952 using a mixture of switchgrass *Panicum virgatum* L., blue grama *Bouteloua gracilis* H. B. K. Lag exSteud, sideoats grama *Bouteloua curtipendula* Michx Torr. and sand lovegrass *Eragrostis trichodes* Mitt Wood. The rate of seeding was 5, 5, 2, and 2 pounds per acre respectively. The seeding was protected from grazing in 1952, grazed lightly in 1953 and moderate use made of it in 1954. During this time, a population of hairy chess *Bromus commutatus* Schrad. was building up so that by the fall of 1954 a thick stand of seedlings was present across the area.

Chemicals selected for the control study were (1) 2,2 dichloropropionic acid (DPA) at 1, 2, 3, and 4 pounds per acre, (2) 3-(p-chlorophenyl)-1,1 dimethylurea (CMU) at 3 and 4 pounds per acre, (3) 3-(phenyl)-1,1-dimethylurea (PDU) at 3 and 4 pounds per acre. Materials were applied with a portable plot sprayer in 40 gallons of water per acre. Plot size was 10 x 20 feet and three replications were established. Each plot was sprayed across the North ½ with a 6 foot boom width on October 21, 1954, and the South ½ of the plot sprayed on April 21, 1955, leaving an untreated strip in the middle. Hairy chess seedlings were 1½ to 2 inches tall at the fall treatment date and about 2 inches tall at the spring treatment date.

August of 1954 was extremely wet with more than 10 inches of precipitation during the month. Rain occurred on 17 of the 31 days. A dense crop of seedlings developed during this period in the loose mulch on top of the soil. This was followed by two weeks of hot, dry weather in September when all seedlings not firmly rooted in the soil were killed. A new crop of seedlings germinated late in September and constituted the main portion of the stand treated on October 21. Winter moisture, November through March, was only 3 inches, or 60 percent of normal.

Results.

Growth of the hairy chess apparently was vigorous at both spray application dates. The warm season grass at the fall application date appeared to be mature with few or no green leaves. At the spring application date, the warm season grasses were showing very little new growth. The following table gives the reaction to treatments for the control of hairy chess and damage to the warm season grass mixture.

Table 1. Effect of three herbicides at fall and spring application dates on hairy chess *Bromus commutatus* and a warm season grass mixture

Treatment		Percent hairy chess control		Percent reduction of warm season grass stand	
Material	Rate lbs./A.	Fall	Spring	Fall	Spring
DPA	1	15	15	0	0
	2	70	70	40	40
	3	85	90	95	75
	4	85	100	95	90
CMU	3	90	95	0	0
	4	95	95	0	0
PDU	3	90	90	0	0
	4	90	95	0	0

Little difference was observed between dates of treatment for degree of control for any rate of chemical. Also little difference between fall and spring treatments was observed on the damage to the warm season grasses. The degree of damage to the warm season grass seems rather severe considering the relatively low rates of chemical used plus the fact that the vegetation was in a more or less dormant condition.

In this area, moisture is often the main limiting factor in obtaining good forage production with a normal rainfall of about 27 inches per year. This was especially true in 1955 when a precipitation deficit of 8.50 inches existed on September 1. Because of this severe drought condition, some rather striking differences in growth were observed in the warm season grass between treated and untreated areas. This growth varied from 2 to 3 feet in height where herbicides had reduced the stands of hairy chess, to only 6 to 8 inches in height in the untreated areas. A thick stand of hairy chess makes large moisture and nutrient demands in the fall, with light use continuing through the winter and heavy demands resumed early in the spring. By the middle of June when the hairy chess was maturing, the soil in the untreated plots was approaching the wilting point with large cracks

XUM

beginning to appear. The warm season grasses were light in color and with only 3 to 4 inches of new growth. Not only was growth on the desirable species short at this time, but they were going into the main growing season with nitrates and moisture depleted to a very low level.

Where fall treatments had controlled the hairy chess, with no apparent damage to the warm season grass, all the fall and winter moisture had been stored, and nitrates elaborated during the period were available for normal early summer growth. The grass in these plots made vigorous growth during the summer with foliage 2 to 3 feet high and a good crop of seed was set. A rich, green color in the grass plus the amount of growth, indicated the nitrates and moisture were adequate, even during a droughty season. Where spring treatments had controlled the hairy chess, the warm season grass responded to an intermediate degree between the two extremes given above. The hairy chess had continued the fall and winter growth with the normal early spring growth demands being made on moisture and nutrients. Although treatment was made April 21, growth demands did not cease immediately but tapered off in varying degrees depending on the effectiveness of the treatment.

Summary.

1. The 2,2 dichloropropionic acid gave satisfactory control of the hairy chess at 3 and 4 pounds per acre but also gave serious reduction of stand in the warm season grasses at these rates. Lower rates were correspondingly less effective in reducing the stands of both types of grasses.

2. The 3-(p-chlorophenyl)-1,1-dimethylurea and 3-(phenyl)-1,1-dimethylurea both gave good control in hairy chess at 3 and 4 pounds per acre with little or no damage to the warm season grasses.

3. Fall control of hairy chess resulted in greatly improved vigor and forage production of warm season grasses the following growing season due to conservation of moisture and accumulation of nitrates. Spring control was intermediate in value.

---

[1] Published with approval of the Director as Paper No. 748 Journal Series, Nebraska Agricultural Experiment Station.

[2] Assoc. Agronomist, Field Crops Research Branch, A.R.S., U. S. Dept. of Agriculture, Lincoln, Nebraska, and Ass't in Agronomy, University of Nebraska, Lincoln, Nebraska.

AN APPRAISAL OF CHEMICAL WEED CONTROL IN FIELD CROPS

H. E. Wood[1]

During the ten years that 2,4-D has been under trial and in use for the control of weeds infesting field crops, great headway has been made in the over-all advancement in weed control. This has been evident in at least two important and far reaching aspects, viz:

1. Those engaged in field crop production have, in 2,4-D and a number of other herbicides, the means of controlling many troublesome weed species.
2. Mainly as a result of the performance of herbicides during the past decade, a weed consciousness has developed on this Continent that has revolutionized weed control thinking.

Progress Made in Chemical Weed Control

Instead of generalizing, the writer has chosen to recount the progress made during the last several years of the use of herbicides in the control of field crop weeds in Western Canada. The area under consideration is devoted in the main to the production of small grains—chiefly wheat, oats, barley, and flax—all spring sown. Rather more than half the 40 milion acres planted annually to these crops is bread-wheat.

In 1947, within this area, the first field use was made of 2,4-D when an estimated half-million acres were treated. By 1950 the acreage had risen to 13½ million, to drop back, due to unfavorable application weather to a little more than 11 million in 1954, but in the past season, 1955, to move up to a record 14 million acres. During the last two years, and particularly this year, MCP has come into use but as yet in only a limited way, for crops that incline to be sensitive to 2,4-D. These include oats, flax, peas and crops that may be underseeded with legumes. TCA has been used successfully for several years in flax and peas to control *Setaria* species, particularly green foxtail.

It may be timely to take "stock" of the headway that has been made in the use of these herbicides, noting at the same time the farmers' acceptance of their use. These are summarized as follows:

1. In the writer's opinion no other agricultural practice in Western Canada has had the ready and wide acceptance as has the use of 2,4-D.
2. 2,4-D has proven a safe, cheap and easily handled product which has been surprisingly effective on a wide range of weed species. Where complete eradication has not been obtained, usually effective control has followed.
3. 2,4-D has definite limitations in that weeds of the grass family, as well as certain species of broad-leaved weeds, are resistant. Already TCA, MCP and other herbicides are complementing 2,4-D. As new chemicals are formulated and prove their worth it is possible that 2,4-D may pass out as a "has been."

Two years ago in attempting to assess the cost of weeds to the farmers of Western Canada, the writer suggested that some ten million dollars was being expended in the purchase of herbicides and their application. During the preparation of this paper it was suggested that I go a step further and estimate the saving resulting from the use of these herbicides. I submit to you my estimate which I have tried to keep on the conservative side.

The procedure was as follows: A survey, which the writer has been making annually, indicated that of the 40 million acres planted to grain crops in Western Canada in 1955, 14,000,000 acres were treated with herbicides. In consultation with field crop authorities, the per cent to the various crops and the saving in per cent of each was agreed upon. Thereafter it was a simple matter to arrive at the bushels and value of the savings effected as indicated in the table that follows:

Savings Through Use of Herbicides in Western Canada Basis. Crop of 1955

	Crop Treated		Savings	In Terms of:	
Crop	Acres	% of Total	Affected	Bushels	Value
Wheat	9,000,000	43.2	10%	20,800,000	$30,000,000
Oats & Barley	4,500,000	25.8	20%	30,000,000	20,000,000
Flax	500,000	25.5	40%	2,200,000	6,000,000
Totals	14,000,000	34.8		53,000,000	$56,000,000

It is gratifying to note that an estimated savings of $56,000,000 resulted from an estimated outlay of $10,000-000 in herbicides control.

Team-work Minimizes Problems

It should not be assumed that progress to date in the use of herbicides has been accidental or one of chance. Coincident with their introduction has been an ever-increasing group of workers engaged in research, experimentation, and promotion. Regional, State and Province weed conferences have been the motivating force in co-ordinating and directing these activities. Such conferences have proven an excellent medium whereby to appraise results, make recommendations to state and provincial weed authorities who in turn have

XUM

made them available to the public. Seldom if ever, has there been finer teamwork and co-operation than has taken place in the furthering of weed control. Here are to be found working as one to further the overall cause, representatives of the Federal Government, States, or Provinces, Universities and commercial firms and organizations. Without these means of promoting the efficient use of herbicides, it would have taken a much longer time to have made the progress that has taken place in recent years.

Fortunately the problems arising from this accelerated interest in weed control have been minimized through these joint efforts. Some of the immediate problems may be listed as follows:

1. As certain types of weeds are eradicated other species become dominant. For example, some of the more easily killed broad-leaved species are followed by harder to combat weeds, such as *Setaria* and wild oats.
2. The problem of convincing the indifferent farmer to use herbicides, when otherwise his untreated fields may become a neighborhood menace.
3. The difficulty of "selling" to farmers the advantages of e a r l y application of herbicides, thereby minimizing weed competition to the growing crop.
4. The ever present danger of a popular means of control, such as herbicides, replacing tried and tested steps in weed control practices that are basic. Herbicides should be considered as complementing rather than as replacing basic weed control practices.

[1] Manitoba Department of Agriculture, Winnipeg, Canada.

RETENTION OF HIGH RATES OF 2,4-D IN THE SOIL[1]

Henry R. Keyser[2]

Introduction

The control of perennial weeds on small areas by the use of soil sterilizing chemicals has been practiced for some time. Both organic and inorganic compounds have been used for such soil treatments. Recently, high rates of 2,4-D applied to the soil have given effective control of certain perennial weeds. Shafer (8) reported almost complete elimination of leafy spurge (*Euphorbia esula*), Russian knapweed (*Centaurea repens*), and hoary cress (*Cardaria draba*) using high rates of 2,4-D. High rates of 2,4-D do not result in prolonged periods of soil sterility such as may result from soil sterilants. Keyser and Sand (4) reported no 2,4-D symptoms and no significant reductions in corn and soybean yields when 40 lb./A of 2,4-D amine or ester were applied five weeks before planting. If we are to use and recommend such a treatment, it is desirable to ascertain the processes which determine the effectiveness of the 2,4-D in the soil. A study of the effects of soil temperature, leaching, microbial and chemical decomposition, and adsorption on clay colloids as related to 2,4-D persistence in the soil must be made. The time lapse between treatment and safe planting date must be determined. The data reported were obtained from an experiment designed to determine under field conditions the rapidity of breakdown of three herbicides applied to the soil at four intervals before planting a crop. The activity of the three herbicides in the soil was measured by the effect on the emergence, height, and yield of corn.

Material and Methods

The experimental area, located on the University of Nebraska North Platte Experiment Station, was irrigated in the fall of 1954. The soil is classified as Hall silt loam with a pH of 7.1. The soil is high in phosphorus and potassium; there is no free lime. The nitrification rate is high. On March 28 and 29 of 1955 the area was plowed, double-disked, and a seedbed prepared. After seedbed preparation, the area was left undisturbed until two days before planting when it was sprayed with Heptachlor to control corn rootworm and wireworm. After application of the insecticide, the area was rotary-hoed lightly.

Soil temperatures were taken at ½, 1, and 3 inch depths at four locations during the five-week period before the corn was planted. The soil temperatures were recorded twice daily at 8:00 A.M. and at 5:00 P.M.

2,4-D amine salt at 40 lb./A, 2,4-D amine salt at 40 lb./A plus boron trioxide at 48 lb./A (Polybor 66.6% boron trioxide), and 2,4-D sodium salt at 40 lb./A plus boron trioxide at 340 lb./A (DB Spray Powder—7% 2,4-D and 59.5% boron trioxide) were applied April 11, 18, 25, and May 2 which was 5, 4, 3, and 2 weeks before planting the crop. These chemicals were applied to the surface of the soil with a knapsack sprayer. A split-plot field design with four replications was used. Dates of application were the main plots and chemical treatments were the subplots.

The plots were two rows wide (40-inch row spacing) and 44 feet long. One untreated row between the two treated rows served as a buffer against spray drift and lateral movement of the herbicides in the soil.

Corn (Nebraska 504) was planted by hand in hills at the rate of four kernels per hill. Hills were spaced 40 inches apart in the row.

Three weeks after the corn was planted, counts were made in each plot to determine the effect the various treatments had on germination and seedling emergence. The plants were grouped into three classes depending upon the degree of stunting, i.e. normal, moderate, and severe. Each hill was then thinned to a uniform stand of two plants per hill. At six and ten weeks after the corn was planted, height measurements of the corn were taken in each plot. The plots were harvested October 25, 1955.

During the five-week period from time of initial chemical application until the corn was planted, 1.37 inches of rain was received. This amount of rain was received in three showers, none of which was over .67 of an inch. During the week following corn planting, 3.04 inches of rain was received; during the second week after the corn was planted, 2.75 inches of rain was received.

Results

Stand count data taken three weeks after the corn was planted are shown in Table 1. 2,4-D sodium salt plus boron trioxide at 340 lb./A caused stand reductions of 46, 57, 51, and 57% when applied 5, 4, 3, and 2 weeks before planting, respectively. Neither 2,4-D amine salt nor 2,4-D amine salt plus boron trioxide at 48 lb./A applied 5 and 4 weeks before planting reduced the stand. However, these two treatments applied 3 and 2 weeks before planting resulted in a 29 and 25% reduction in stand for the former and a 35 and 25% reduction in stand for the latter.

Table 1. Effect of three herbicides applied to the soil at four dates before planting on stand of corn.

Treatment		Per cent reduction in stand when compared with untreated control[1] Weeks before planting			
Herbicide	Rate lb/A	5	4	3	2
2,4-D Amine	40	None	None	29	25
2,4-D Amine + B_2O_3	40 48	None	None	35	25
2,4-D Sodium + B_2O_3	40 340	46	57	51	57

[1] Average of four replications.

The analysis of height measurement data taken six and ten weeks after the corn was planted showed that 2,4-D sodium salt plus boron trioxide at 340 lb/A caused statistically significant reductions in the height of corn at all dates of application. 2,4-D amine salt did not cause a significant reduction in height at any of the dates it was applied. 2,4-D amine salt plus boron trioxide at 48 lb/A caused a statistically significant reduction in height only when applied three weeks before planting.

A summary of the means of corn yields for treatments and dates of application is given in Table 2. Only when 2,4-D amine salt was applied two weeks before planting did this treatment cause a statistically significant reduction in corn yield.

Table 2. Persistence of three herbicides applied to the soil at four dates before planting as measured by the effect on corn yields.

Treatment		Yield of corn as affected by time of applying herbicides to the soil [1] Time of application in weeks before planting				
Herbicide	Rate lb/A	2	3	4	5	Average
		Bu/A	Bu/A	Bu/A	Bu/A	Bu/A
2,4-D Amine	40	63.5	67.2	78.6	78.4	71.9
2,4-D Amine	40	66.3	60.9	72.8	74.9	68.7
+	+					
B_2O_3 [2]	48					
2,4-D Sodium	40	9.8	16.2	7.8	17.9	12.9
+	+					
B_2O_3 [3]	340					
Check		80.1	77.7	78.5	77.4	78.4
Average		54.9	55.5	59.4	62.2	

L.S.D. at 5% level between treatment means at the same date=11.3 bushels.

L.S.D. at 5% level between date means within a treatment=10.8 bushels.

L.S.D. at 5% level between treatment means=5.7 bushels.

L.S.D. at 5% level between date means=4.6 bushels.

[1] Yields based on 15.5% moisture. Average of four replications.

[2] B_2O_3 applied as Polybor (66.6% B_2O_3) at 72.3 lb/A.

[3] B_2O_3 and 2,4-D applied as DB Spray Powder (7% 2,4-D and 59.5% B_2O_3) at 571.43 lb/A.

The application of 2,4-D amine salt plus boron trioxide at 48 lb/A at five and four weeks before planting did not cause statistically significant yield reductions. However, this treatment applied three and two weeks before planting caused statistically significant reductions in corn yield.

Applications of 2,4-D sodium salt plus boron trioxide at 340 lb/A made 5, 4, 3, and 2 weeks before planting all caused statistically significant yield reductions. There was no statistically significant difference between dates of application for this treatment.

2,4-D amine salt plus boron trioxide at 48 lb/A applied three weeks before planting resulted in statistically significant reductions in yields below those obtained when this treatment was applied five and four weeks before planting.

There was a statistically significant reduction in yields when applications of 2,4-D amine salt were made three and two weeks before planting as compared to yields obtained when this treatment was applied five and four weeks before planting.

The weekly average soil temperatures at planting depth (average of temperatures at 1 and 3 inch depths) are given in Table 3.

Table 3. Weekly average soil temperatures at planting depth from April 11-May 9, 1955[1]

Date	Weeks before planting	Temperature in Degrees Fahenheit at planting depth[1]
April 11-17	5	61
April 18-24	4	70
April 25-May 1	3	69
May 2-May 9	2	77

[1] Planting depth temperatures are an average of the soil temperatures at 1 and 3" depths taken at 5:00 P.M. daily.

Discussion

Applications of herbicides to the soil are subject to chemical and microbial decomposition, leaching, adsorption on the clay fraction of the soil, and volatilization. All of these influence the persistence of herbicides in the soil.

Rains of .62, .66, .02, and .07 inches fell during the five-week period from time of initial chemical applications until the corn was planted. This amount of rain over a five-week period would not result in an appreciable loss of the herbicides from the soil due to leaching. It does not appear that in this test leaching was a major factor in the disappearance of the herbicides from the soil during the five-week period. Ogle and Warren (6) reported that eight surface inches of water are required for complete removal of 2,4-D in a silt loam soil. Crafts (2) found that complete removal from the soil of 2,4-D was not accomplished in two soil types with 320 surface centimeters of water. Nutman, Thornton, and Quastel (6) found that 2,4-D was not completely removed from a Rothemsted soil by 5.6 inches of water.

Soil temperatures at depth of planting two weeks before planting were 16° F. higher than soil temperatures five weeks before planting. Past experiments have shown that with increased soil temperatures, an abundant supply of organic material, favorable soil reaction, and adequate soil moisture, there is an increase in the population and activity of micro-organisms. With increased biological activity, an increase in the rate of decomposition of herbicides in the soil is to be expected. Ogle and Warren (7) found that the disappearance of 2,4-D was proportional to the temperature, with inactivation of 2,4-D most rapid at 35°C. and slowest at 8°C. Mitchell and Marth (5) found the rate of inactivation of 2,4-D is rapid in moist soils having a high organic matter content and that 2,4-D is inactivated in moist soils in the absence of leaching. They also found that in autoclaved soil treated with 2,4-D and stored for two weeks, the 2,4-D still persisted whereas in non-autoclaved soil treated with 2,4-D and stored for two weeks, the 2,4-D was inactivated.

The soil temperatures at depth of planting two weeks before planting were approximately 77°F. which is near optimum for biological activity. 2,4-D amine and 2,4-D amine salt plus boron trioxide at 48 lb/A were partially inactivated even in two weeks.

Examination of the data reveals that the activity of the herbicides in the soil was influenced by the length of time the herbicides remained in the soil and by the soil temperatures during that period. The longer herbicides remain in the soil and the nearer soil temperatures are to optimum for biological activity, the greater the degree of inactivation of the herbicides. Brown and Mitchell (1) reported that soil treated with 2,4-D at 10 lb/A and stored at 70°F. was inactivated completely in two months whereas soil treated with 2,4-D at only 2 lb/A and stored at 36°F. was still highly active at the end of two months.

The presence of a small amount of boron trioxide (48 lb/A) with 2,4-D did not alter the rate of herbicide breakdown. When 340 lb/A of boron trioxide was used, chemical breakdown appeared to be much slower. This may be due either to boron toxicity, suppression of microbial activity, a tie-up of 2,4-D, or a combination of all three.

XUM

Summary

The rapidity of breakdown of three herbicides applied to the soil at four intervals before planting was studied. The activity of the herbicides in the soil was determined by the effect on the emergence, height, and yield of corn. Studies to determine the time lapse between time of chemical application and safe planting date were conducted. Soil temperatures were recorded in an attempt to establish a relationship between breakdown of herbicides, soil temperature, and biological activity. The herbicides varied greatly in their rate of inactivaton. 2,4-D sodium salt at 40 lb/A plus boron trioxide at 340 lb/A was the most persistent, followed by 2,4-D amine salt at 40 lb/A plus boron trioxide at 48 lb/A, and 2,4-D amine salt at 40 lb/A.

Literature Cited

(1) Brown, James W., and Mitchell, John W. Inactivation of 2,4-dichlorophenoxyacetic acid in soil as affected by soil moisture, temperature, the addition of manure, and autoclaving. Bot Gaz., 109: 314-323. 1948.

(2) Crafts, A. S. Toxicity of 2,4-D in California soils. Hilgardia, 19: 141-158. 1949.

(3) DeRose, H. Robert. Persistence of some plant growth regulators when applied to the soil in herbicidal treatments. Bot. Gaz., 107: 583. 1945-46.

(4) Keyser, H. R., and Sand, P. F. Application of high rates of 2,4-D to the soil previous to planting soybeans and corn. North Central Weed Control Conference Research Report, 11: 65 and 73. 1954.

(5) Mitchell, John, and Marth, Paul C. Germination of seeds in soil containing 2,4-D. Bot. Gaz., 107: 408. 1945-46.

(6) Nutman, P. S., Thornton, H. G., and Quastel, J. H. Inhibition of plant growth by 2,4-dichlorophenoxyacetic acid and other plant growth substances. Nature, 155: 498-500. 1945.

(7) Ogle, R. E., and Warren, G. F. Fate and activity of herbicides in soils. Weeds, 3: 257-273. 1954.

(8) Shafer, N. E. Soil applications for the control of the deep-rooted perennial weeds. North Central Weed Control Conference Proc. 11: 56-59. 1954.

1 Published with the approval of the Director as Paper No. 753 Journal Series, Nebraska Agricultural Experiment Station.
2 University of Nebraska and Division of Noxious Weeds, North Platte Experiment Station, North Platte, Nebraska.

FIELD EXPERIENCES IN 1955 WITH DEFOLIATING CHEMICALS AS AN AID TO HARVESTING DRY EDIBLE BEANS

Leslie R. Reed[1]

On September 13, 1954, Dr. Alvin R. Hamson of the Vegetable Crops Department at Cornell, wrote as follows in a special letter to all growers of dry edible beans in New York State:—

"The prospects for wide-scale use of defoliants on dry beans have developed so rapidly the last two weeks that I feel that it is advisable that I should send you what information we have to anticipate questions which will shortly arise." This was the culmination of several years' work by Dr. Hamson's department and which has started what amounts to a chain reaction of interest across the country.

Bean defoliation with chemicals (and throughout this paper the word "beans" is used to describe those grown for dry edible purposes) is a new practice that had its inception in the demand from New York bean growers for some means of speeding up the bean harvest. The demand has not, however, been confined to New York State, but has arisen from time to time in all the main bean growing areas in the country, including Michigan, California and the Pacific Northwest.

In New York: Dr. Hamson's earlier work on Red Kidney and White Bean varieties, showed that there are a number of outstanding advantages in defoliating beans. These he summarized as follows:

1. Hastens maturity and drying and the possibility of earlier harvesting for timely planting of wheat and other Fall crops.
2. Reduces delays in harvesting, because of unfavorable weather conditions especially following late planting and the excessive use of nitrogenous fertilizers.
3. Permits threshing of beans directly after pulling with elimination of drying in the windrow.
4. Hastens drying of late maturing areas and thus promotes even ripening of the entire crop.
5. Assures quicker drying to 18% moisture or less thus reducing dockage and storage problems.
6. Reduces percentage of immature discolored and moldy beans.
7. Reduces bean losses due to shattering during harvesting operations.
8. Reduces likelihood of stones getting into the combine due to elimination of the necessity of turning the beans in the windrow.

The big incentive to growers among all these advantages is the possibility of allowing the beans to dry out attached to the soil thus eliminating the weather hazards involved when beans are laid in the windrow to dry.

All or most of these advantages have been experienced during the 1955 season in commercial and semi-commercial applications in New York State, in Michigan, and in the Pacific Northwest.

1955 was not a good year in which to introduce the new practice of bean defoliation. The crop was generally well below average in New York and in Michigan due to the poor set of flowers in the very hot weather. The production of a second crop of flowers later did little to help, as the chance of the late crop maturing before frost was poor.

In spite of the season with the promise of low yields, there was a marked interest among farmers, although in New York State only some 6,000-7,000 acres was actually defoliated on a commercial scale.

In Michigan: The practice of bean defoliation was completely new to growers, although some test work with Endothal in 1954 indicated that this chemical was not suitable for this purpose.

Dr. Hamson's work in New York in 1954 had, however, shown that Shed-A-Leaf—the Chipman sodium chlorate/borate defoliant, originally developed for cotton, could be used with safety as a spray on both Red Kidney and White Navy Beans. It was necessary, however, to test its effect on the variety Michelite the predominating variety grown in Michigan before permitting it to be used commercially in that State.

Following a preliminary survey of the main bean counties in Michigan, made in the Fall of 1954, plans were made in early 1955 for a series of large scale field demonstrations with Shed-A-Leaf in six of the main bean counties. These plans were discussed with Dr. Grigsby of the Botany Department of MSU and with the Extension people who promised their full support in making the necessary arrangements with the County Agents. The Michigan Bean Co. was also

XUM

keenly interested in the outcome of the demonstration, and offered full support. It was planned to lay down some 40 plots of 2-5 acres in extent (actually nearly 50 were completed) on which to make observations. The demonstration fields were selected in July and early August with the help of the County Agents. Arrangements were also made to start spraying the earlier maturing fields at the end of August and to invite farmers through the press and radio to come to see the applications made, and to view the results later. Observations were also to be made with moisture records on the rate of defoliation and drying out of the crop. These results will be discussed later.

As an indication of the interest shown, many of these demonstrations were visited by parties of as many as 30 or more farmers at a time; from the point of view of attracting attention, they were successful beyond all expectations. They also confirmed the value of using a defoliant to hasten the harvest.

Before discussing the results in further detail, some words about the application problems involved are in order.

Application Problems: In New York the predominating variety is Red Kidney which has an upright habit of growth and is usually planted in 34 inch rows, thus there was no problem in using a tractor mounted sprayer, at least not in 1954. Airplanes were used as well in that year to test the feasibility of this method of application and it proved most successful. In 1955 bean growth in New York was heavy and farmers were reluctant to try the new practice with ground sprayers, as they did not want to damage their crops with the tractor wheels. Most of the 6,000 acres sprayed in New York State in 1955 was, consequently, sprayed by airplane.

In Michigan a similar but more acute problem existed. Here the predominating variety, Michelite, of spreading habit is grown in 28 inch rows, which results in complete coverage of the ground at harvest. This appeared to rule out all possibility of using ground sprayers, although most of the beans are grown in small fields which it would not be feasible to spray by airplane. Another problem was the dearth of air applicators in this part of Michigan, who could spray on a sufficient volume to give adequate coverage (a minimum of 6 gals/A was required.) In due course both of these problems were solved, the first by encouraging the development of efficient vine lifters which could be fitted on to any tractor, and the second by importing out-of-state air applicators who could put on the required volume of spray.

With the exception of two, all 43 demonstrations in Michigan were applied by airplane, the usual swath width being 35 ft. The spray boom was fitted with D8 nozzles placed 2 ft. apart. Usual height flown above crop was 2 to 5 ft.

At two centers, application was made by a small ground sprayer (loaned by the Botany Department MSU) using the special vine lifting equipment already referred to, mounted in front of each of the four tractor wheels. This equipment was made and fitted by the Hopkins Manufacturing Company of Saginaw. Many farmers became interested in these vine lifters as the season progressed, and quite a few sets were purchased. These lifters proved very successful even in heavy vines, and are not too costly.

The sprayer used for ground application was fitted with cone nozzles, (¼T No. 12) spaced 20" apart on the spray boom, and at a height of about a foot and a half above the crop. The pressure used was 30 to 40 lbs. per square inch, the sprayer covering eight, twenty-eight inch rows at a time. No drop legs were used in these tests, although drop legs are considered necessary in New York where the less viney variety Red Kidney seems to require it to obtain good coverage.

The wider availability of these vine lifters will undoubtedly help to popularize the use of defoliants on beans. Many farmers are reluctant to spend money on air application, apart from the fact that their fields may be too small or unsuitably placed for aerial work.

Materials and Rates Used:

In addition to a series of small scale field plots laid down by the Botany Department of MSU comparing different defoliants, a comparison of Magron[1], Shed-A-Leaf[2] and Shed-A-Leaf L[3] was made in three fields scale demonstration plots, two of which were applied by ground equipment.

Application rates were based on the results obtained in New York State last year, Shed-A-Leaf being applied at 7½ lbs. per acre in the form of a soluble powder, and 1½ gallons per acre in the liquid Shed-A-Leaf L formulation.

1. Magron — a liquid containing 40% Magnesium Chlorate—A Dow Chemical Company product.
2. Shed-A-Leaf—a soluble powder containing 40% sodium chlorate with sodium metaborate—A product of Chipman Chemical Company, Inc.
3. Shed-A-Leaf L—a liquid formulation containing 18% sodium chlorate with sodium metaborate—A product of Chipman Chemical Company, Inc.

In some instances 10 lbs. and 2 gallons were tried where bean foliage was green or excessively heavy. Magron was applied at 3 qts. per acre. All materials were applied in 6 gallons of water per acre by air, and in 15 to 20 gallons of water per acre by ground sprayer. It had also been planned to try out some dust defoliants but lack of equipment necessitated dropping the project for 1955. The following is a general summary of the results obtained:

Results of Tests and Demonstrations in Michigan

1. Only six test plots failed to show satisfactory response to defoliation, (two of these showed none at all).
2. Four of these six plots (all in Huron County) had inadequate dosage applied, due to the inability of the airplane at that time to apply more than 3½ gallons per acre.
3. Shed-A-Leaf at 7½ lbs. of soluble powder or 1½ gallons of the Shed-A-Leaf L formulation appeared to be adequate this season both for ground and air application. Magron at 3 qts. per acre also gave good desiccation and defoliation.
4. In all the other demonstrations the farmers on whose beans they were made, expressed themselves as well satisfied with the results. In many cases these cooperating farmers had a further acreage sprayed commercially, and others who visited the demonstrations requested commercial application on their own beans.

   Dr. Grigsby visited a number of test plots in Saginaw and Huron Counties including both air and ground applications, and also saw the results of some commercial applications of Shed-A-Leaf in the Saginaw area.

General Effects of Defoliation in Michigan Demonstrations are summarized as follows:

1. Rapid fall of leaves (3-7 days after application).
2. Rapid drying of the bean plants, including pods.
3. Rapid fall in moisture content of beans.

A few farmers took advantage of this, and pulled defoliated beans as soon as they saw that they were ready and combined them either the same or the next day. The majority of farmers, however, left their beans unharvested until the untreated areas caught up with the treated, days or even weeks later. This

XUM

meant that the treated areas were often over-ripe by the time they were harvested.

Defoliation and drying out of these early and mid-season beans was rapid and the date of harvest was advanced by two weeks or more as compared with untreated portions of the same field. On later beans, defoliation was slower, especially where nights were cool.

Defoliation and Effect on Moisture Content of Beans

Moisture tests and observations were made at 13 centers. It was obvious from these, that defoliation had a marked affect under the conditions existing in Michigan this season in bringing about a very much quicker drying of the standing beans than that which occurred when beans were pulled and windrowed in the usual way, and left to dry out on the ground. Eighteen percent is the acceptable moisture content of dried beans in New York and Michigan, above which there is a penalty which includes a deduction of 2 lbs. of weight per hundred weight for each 1% over 18% and a charge for drying.

It was noticed in those plots in which moisture determinations were made, that defoliated beans reached the desired 18% moisture level or below very quickly while standing. The data from eight of the thirteen moisture tests made have been averaged to illustrate this. Average moisture content of treated beans fell to 14.73% in an average time of 11.8 days while untreated beans in the same period fell to only 20.37%.

It was also found that beans that had been defoliated previously could be pulled and combined either the same day or within 24 hours of pulling if weather permitted, a marked saving of time, and with a minimum risk of damage to beans if the weather should turn wet during the harvesting operation.

The possibilities for a combine harvester for beans to handle the crop directly from the standing row has always been obvious. The wider use of defoliants makes the possibility even more attractive and the problem has been referred to farm machinery manufacturers for their consideration.

Weather during the test period of the earlier demonstrations was generally fair and hot, with temperatures often in the 90's. These conditions helped beans to dry naturally and also favored rapid defoliation. Elevator managers complained as the season progressed of too many split beans, due to beans being too dry. In these circumstances, it would have been easy to blame the use of defoliants, but fortunately, all cases recorded except one, occurred in beans that had not been treated. Farmers who use defoliants in the future, will have to be careful that beans do not become too dry before pulling and combining.

Effect of Defoliation on Tendency to Shattering

At no center did beans treated with Shed-A-Leaf or Magron develop a greater or lesser tendency to shatter in the field or during harvesting operations than did untreated, in spite of their usually lower moisture content.

Effect of Defoliation on Yields

In New York State trials in 1954, defoliation actually increased yields per acre of marketable beans by lowering the percentage "pick". Although no similar studies were undertaken in Michigan this year, it is conceivable that the practice could reduce yield if application was made too early.

Early applications should, therefore, be avoided. The best defoliation in any case is likely to be obtained when foliage is beginning to show signs of yellowing —an indication that the abscission layer between leaf and stem is beginning to form naturally. When application is made at this stage no reduction of yield should occur. On the Red Kidney variety defoliation can be carried out when beans inside the pods begin to show pink.

Marking of Pods and Beans

In last years tests carried out at Cornell, considerable marking of both pods and beans was noticed with certain chemicals used as defoliants. Shed-A-Leaf, however, was one of the few, if not the only one, to show no marking of White Beans, even at higher rates than those normally recommended.

In Michigan, very special care was taken to observe if there was any sign of marking, and not one instance was recorded, although some blotching and spotting on the outside of the pods was often noticed.

Effect of Drift on Other Crops

The effect of spray drift on sugar beet, corn and alfalfa was recorded when this occurred, and the following summarizes the findings. **Sugar Beet:** leaves became mottled and brown and later some of the outer leaves actually died, although heart leaves were generally unaffected. It is doubtful whether this would affect sugar beet adversely at this late season, but nevertheless it is recommended that Shed-A-Leaf spray should not be allowed to drift onto this crop. **Corn:** leaves became spotted and streaked. Later the leaves dried up much more rapidly than the leaves on unsprayed corn. This had no apparent deliterious effect on the grain which had reached the dent stage, an application of Shed-A-Leaf may even help to ripen off the crop and hasten harvest. **Alfalfa:** although drift spotted the leaves it did not seem to have any permanent injurious effect.

Effect on Weeds Present in the Crop

At the rates of Magron and Shed-A-Leaf used for defoliating beans, very few weeds showed much effect. In Michigan milk weed (*Asclepias syriaca*) and smartweed (*Polygonum persicaria*) showed the most marked effect and were often completely desiccated by the time the beans were ready for pulling. Other weeds such as mustard, Canada thistle and sow thistle and in New York State heavy infestations of pigweed were spotted, but were not seriously affected. Where weeds are a major problem, heavier rates than those normally required for defoliation could be used to help dry up the weeds as well as the beans before pulling.

Effect on Beans with Mosaic

There were several cases where test fields had a noticeable number of bean plants affected with what appeared to be one of the mosaic diseases. These virus affected plants were most conspicuous in sprayed fields because they would not defoliate normally. Dr. Axel Anderson of the Plant Pathology Department MSU, inspected one of these fields with the writer, and confirmed the presence of mosaic, and expressed the view that such plants might not readily translocate chemicals.

The Effect of Very Green Foliage on Defoliation

It was noticed throughout the demonstration series that bean plants in this stage of growth would not defoliate readily with 7½ lbs. of Shed-A-Leaf per acre. When a higher rate (10 lbs.) was used the leaves became brown as though slightly frosted but no better defoliation resulted.

One test deliberately applied to beans in this stage, showed no signs of defoliation five days later when frost intervened.

It is concluded from these limited observations and from commercial applications that where defoliation is desired such beans should not be sprayed until they reach a more advanced stage of maturity. If the lateness of the season prohibits waiting then a higher rate of application (10 to 12 pounds per acre) can be made which will cause the leaves to dry up as though frosted and thus hasten the desiccation of the pods and beans.

XUM

This worked very well in New York State on Red Kidney this season.

In only two instances did rain follow close enough to application of Shed-A-Leaf to be considered as a possible cause for failure. The tests in New York State in 1954, indicated that even heavy rain, provided that it does not fall within six hours of application, is not likely to interfere seriously with the results.

Effect of Defoliation on Pick

The term "Pick" (used generally throughout the bean industry) refers to the foreign matter and moldy and damaged beans which are removed in the cleaning process in order to bring up to grade. A picking charge is made (on the pounds of defective material actually removed) of about 7¢ per pound on Red Kidney in New York, and 8¢ a pound on White Beans elsewhere.

This season the weather was so hot and dry during the demonstration tests in Michigan that little or no difference in regard to moldy beans could be expected. For this reason no actual comparisons of pick were made. Later maturing beans caught in the wet period that followed could not be harvested, owing to the physical impossibility of getting a combine into the fields. This applied to both defoliated and non defoliated beans in New York and Michigan.

Results on Late Maturing Beans and Effect of Temperature

It is with late maturing beans that the greatest harvesting troubles are usually experienced. In these demonstrations the use of Shed-A-Leaf and Magron has helped to bring about earlier drying of late maturing beans just as well as earlier maturing beans. However, it has been found that the time taken for the leaves to drop is usually longer (from 7-10 days) depending largely on the temperature. The lower the temperature the longer defoliation takes. As previously mentioned this should be taken into account when defoliants are to be used on late maturing beans towards the end of the season, when consideration should be given to using higher rates to achieve desiccation rather than defoliation.

Defoliation of Varieties Other Than Michelite

Shed-A-Leaf was tried only on a limited scale at one center in Michigan on the varieties Dark and Light Red Kidney, Cranberry, and Yellow Eye. This was in the variety test plots of the MSU in Montcalm County. Shed-A-Leaf was flown on at 7½ lbs. per acre in 6 gals. of water. It was also used commercially at the same rates on twelve acres of the variety Pinto, in the neighboring county of Gratiot. The results showed that while the kidney varieties, Cranberry and Pinto responded well, the variety Yellow Eye did not. This may have been due to this variety being too green at time of application. This will have to be checked another season.

Germination of Treated Beans used for Seed

No tests have so far been made in Michigan to check if the use of Shed-A-Leaf or other defoliants is likely to affect adversely the subsequent germination of the beans if used for seed. Some tests were carried out last year at Cornell, and no adverse effect was then noted. Germination tests are being arranged with beans sprayed this season in California.

Residue Data

Following up on the negative residue determinations made on sprayed beans from the Cornell (N. Y. State) tests last year, samples of both pods and beans from a number of the sprayed and unsprayed plots in Michigan were taken in 1955 for chemical determinations of residual chlorate and boron. Even when using more sensitive analytical methods than those used in 1954, no added boron could be found in the beans themselves, and only a very small residue on the pods. In one instance the untreated pods showed the presence of 37.5 parts per million where the treated showed 50. So far it has been impossible to demonstrate the presence of any sodium chlorate as a residue, presumably owing to the rapid breakdown of this chemical in the presence of moisture and organic matter. It would seem that there is no residue problem with this material when used at recommended rates. This work is being repeated, however, on pods and beans from the 1955 New York experimental plots.

Costs and Economics of Defoliation

The cost of chemical will vary from about $1.75 to $2.40 per acre depending on the amount used. Aerial operators this year in Michigan, and New York charged $3.00 per acre for small acreage for application, which was not unreasonable considering that 6 gals. per acre had to be applied. To a farmer using his own ground sprayer the cost per acre would be considerably less. Assuming a total cost of $4.75 for application and chemical, and a market price for beans of $7.00 per 100 pounds, a saving of a little over one bushel of beans per acre would pay for the whole defoliation cost. Such a saving could readily be achieved in most seasons, and in others the saving would be considerably more. Farmers and county agents with whom the matter was discussed considered the practice to be economically sound, and in addition it assures a dryer and cleaner crop in a shorter time with less risk of weather damage.

Summary

The use of certain defoliants previously found suitable for defoliating dry edible beans in N. Y. State, have proved equally satisfactory in 1955 for Michigan conditions, for assisting in earlier harvesting and for reducing risks due to bad weather. Defoliants can be used as such or as desiccants to speed up moisture reduction in the plant parts. Air and ground spray applications are equally effective but the latter presented certain problems which have been overcome by the development of an efficient vine lifter attachment, to be fitted to the tractor to prevent wheel damage to the crop. Analytical studies made with Shed-A-Leaf defoliant indicate that residue problems are unlikely with this material. The economics of using defoliants or beans are briefly discussed.

1 Chipman Chemical Company, Inc.

RESPONSE OF CANADA THISTLE (*CIRSIUM ARVENSE*) TO AMINO TRIAZOLE

Oliver C. Lee[1]

There is a demand for an effective and economical treatment that will eradicate Canada thistle. Farmers and land owners are aware that an infestation of Canada thistle is not only a menace to the farm on which it is growing, but to the entire community as well. Windborne seeds of the plant are often carried for miles. Reports indicate that more than 750,000 acres of land are infested in the North-Central states. Three distinct varieties of *Cirsium arvense* are found in this area varying principally in leaf structure from a lobed to almost an entire leaf. 2,4-D and sodium chlorate are the most generally used herbicides for Canada thistle control. Sodium chlorate is effective, but the amount required is too costly to be practical on other than small areas. Spraying with 2,4-D is practical for retarding growth and reducing the stand. Complete control or eradication is seldom obtained with 2,4-D.

Studies to determine the response of Canada thistle to applications of amino triazole (3-Amino-1,2,4-triazole) were started at Purdue University in 1954. Applications were made on May 13 using rates of 2, 4 and 8 pounds

XUM

per acre of actual ingredient. The material was applied as a spray using 150 gallons of water per acre. The tallest plants at that time were approximately 15 inches in height. First symptoms of response of Canada thistle to amino triazole were noted some six days after the treatment. Plants became chlorotic. The material apparently is translocated through the plants including the extensive root system, as indicated by albinism of new growth arising from root stalks. Chlorotic new growth continued to emerge throughout the summer and fall, but most of these plants did not survive. By fall the 4 and 8 pound rates had reduced the stand of normal plants to less than one percent of checks. A year later, on September 28, there were 22 plants per square yard on check plots, and 4.0, 0.4 and 0.5 plants on plots treated to 2, 4 and 8 pounds of amino triazole, respectively. A portion of the plots, described above was clipped seven days after sprays were applied. Plant counts on these plots were 19, 8, 6 and 6 per square yard for checks and treatments of 2, 4 and 8 pounds per acre, respectively. Clipping reduced the effectiveness of the treatments.

Poor results were obtained with applications made on October 21. Two and four pounds gave no results. The 8 pounds reduced the stand approximately 50 percent.

Results of more detailed trials made in 1955 have followed the same pattern as those obtained in 1954. These experiments were designed to determine the effect of various rates, the most susceptible stage of growth, and the residual effect on crops planted following the treatment.

On May 16, when Canada thistles were 6 to 10 inches in height, a series of plots were sprayed using 4, 6 and 8 pounds per acre of amino triazole. Thirty gallons of water per acre were used in these experiments. Final observations and plant counts were made on October 6. Amino triazole at rates of 4, 6 and 8 pounds per acre reduced the stand of Canada thistle from 2489 plants on check to 4, 2 and 1 plants per plot for treatments, respectively. Plots were 576 square feet in area.

Other plots, 1 square rod in size, were treated with 4, 6, 8, 10 and 12 pounds of amino triazole per acre on June 5, when plants were 12 - 15 inches tall. Plants surviving on plots on October 6 were as follows: Checks —710, treatments of 4, 6, 8, 10 and 12 pounds; 26, 9.6, 5.6, 5.3, and 3.0 plants per square rod, respectively.

Results with 4 pounds of amino triazole applied on July 27, when Canada thistles were in late bloom stage, were not very encouraging. Tops were killed, but considerable regrowth of normal green plants was evident on October 25 when last observations were made. Results with combinations of 2,4-D and amino triazole were poor. Results of 4 pounds of amino triazole and 2 pounds of 2,4-D (ester) per acre were inferior to 4 pounds of amino triazole alone.

To further check the merit of amino triazole for Canada thistle control, the material was made available to several farmers through County Agents. Thirty-two treated areas were checked during the fall. Results, as a whole, of applications made by farmers were not as satisfactory as those obtained on experimental plots. It was interesting to note that, when amino triazole was applied with a boom-equipped field sprayer using 10 gallons of solutions per acre, results were not as good as applications made with knapsack sprayers using 30 or more gallons of solution per acre. On only one occasion a 99 percent kill of thistles was estimated when 10 gallons of spray per acre were used. This particular area was practically free of all vegetation other than Canada thistle. The spray was applied on May 16 at which time the Canada thistles were about 8 inches in height. Five pounds of amino triazole per acre applied with a field sprayer to Canada thistle in a timothy field resulted in only a 50 percent reduction in stand.

Areas infested with Canada thistle were sprayed with 4 pounds of amino triazole in early May, plowed or disked 14 and 16 days later, and then planted to corn and soybeans. No symptoms of injury were noted to either the soybeans or corn. A few corn plants showed symptom of chlorosis on plantings made 10 days after spraying. The percentage of Canada thistle control was reduced slightly as compared to treatments made on undisturbed areas. Results were encouraging, however, as all new growth occurred late in the season resulting in dwarf plants that caused little competition to the crops.

Conclusions:

Canada thistle appears to be most susceptible to amino triazole in early stages of growth or up to the bud stage.

Four pounds of amino triazole per acre may be considered the minimum dosage.

Symptoms of injury due to amino triazole were not observed on corn and soybeans planted 14 days or more after spraying to control Canada thistle.

Pre-planting treatments were most promising as Canada thistle usually produces considerable top growth several weeks before normal corn and soybean planting time.

Inadequate gallonage of spray may result in a poor kill, especially when Canada thistle plants are protected by other vegetation.

1 Purdue University, Lafayette, Indiana.

CONTROLLING CANADA THISTLE WITH LATE FALL TREATMENTS OF HERBICIDES

G. F. Ham, D. D. Bondarenko, and C. J. Willard[1]

There are numerous reports of the successful use of 2,4-D at rates ranging from 20 pounds up to 100 pounds per acre in the late fall to control various perennial weeds which are otherwise difficult to control. Canada thistle is unquestionably the No. 1 weed problem in Ohio, and it seemed very much worth while to try this technique on Canada thistle.

We were unable to start in the fall of 1953, but an experiment was started by the senior author on February 22, 1954. It included 10, 20, 30, and 40 pounds per acre of both amine and ester forms of 2,4-D in triplicate, applied to square-rod plots. It is not necessary to give individual reports on these treatments. They looked extremely favorable in April. The untreated thistles had made a considerable start and the treated plots were bare. However, they began to show sprouts just a little later, and by June it was almost impossible to distinguish the treated plots. Corn and soybeans were planted in the treated plots with no injury, showing that the 2,4-D was completely gone. The only practical effect, therefore, was a two or three weeks' delay in the appearance of the thistle sprouts, with no eradication effect.

Since fall treatments are the suggested technique, a considerable series (180 plots) of fall treatments were put in by the senior author on November 1 and November 20, 1954. Both amine and ester forms of 2,4-D were used in rates ranging up to 30 pounds per acre, in triplicate plots. Again, the first appearance of the thistle sprouts was delayed, but by late May there were numerous healthy sprouts in every plot regardless of the rate or date of application, the cultural treatment following application, or the formulation used. The thistles on the treated plots were shorter when these were taken in May, and the plots plowed than were the thistles in the check plots, but they were growing so vigorously as to leave no doubt about the final results. The thistles were not eradicated or even seriously injured.

Our conclusion is that under Ohio climatic conditions heavy fall treatments with 2,4-D on Canada thistles are decidedly unpromising.

XUM

At the same time that we did this work with 2,4-D in 1954 we also applied amino-triazole to Canada thistles at 2, 4, and 8 pounds per acre, using triplicated square-rod plots, as well as a few others for observation. In the spring of 1955 there was comparatively little difference between the check plots and those treated with 2 pounds per acre. However, the ones treated with 8 pounds per acre were nearly, although not quite, free of thistles in May, 1955. Some of these plots were undisturbed, and even in October, 1955, there was still a 50 percent reduction in the number of thistle plants in the plots which received 8 pounds per acre of Amizol eleven months earlier. This suggests that fall applications of Amizol may be worth studying as a means of Canada thistle control.

The second author initiated an extensive program on the use of Amizol on Canada thistles beginning in the spring of 1955. Most of these plots will be left until the spring of 1956 for final evaluation, but it is clear that Amizol is much the most favorable chemical that we have used at any time for Canada thistles. There is, however, still an immense amount of work to do in finding out just how best to use it.

The most promising lead, for the southern part of the Corn Belt, at least, is to spray the thistles in vigorous rosette stage (April 28 to May 5 at Columbus) with about 4 lb/A amino-triazole, *plow* 14 to 21 days later, and plant corn. Corn has not been injured by Amizol in this way, and the thistles were 90-95 percent controlled.

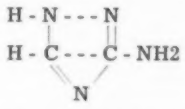
[1] The Ohio State University and Ohio Agricultural Experiment Station.

AMINO-TRIAZOLE IN CONTROLLING PERENNIAL WEEDS

Thomas K. Pavlychenko[1]

1. Characteristics of the Chemical.

Amino-1,2,4-triazole, known under the commercial name of Amizol, is a comparatively recent newcomer into the group of systemic herbicides. It is a five-membered ring compound with three nitrogens attached at the first, second and fourth positions on the ring:



3 - Amino - 1,2,4 - triazole

Its main avenue of lethal attack on plants lies through the destruction and interference with normal functioning of the chlorophyl. Depending on the rates used, the subsequent reduction in photosynthetic processes results either in a stagnation of growth with possible recovery, or a total death of plants, due to imposed starvation resulting in excessive respiration and decay.

During the past three years a considerable amount of of experimental work with Amizol was carried out both under greenhouse and field conditions. The characteristics of the chemical and the range of susceptible plants weeds, woody plants and crops, were rather widely investigated in the United States, Canada and in many overseas countries. These studies, incomplete as they are, give us a considerable body of information with respect to the main characteristics of the chemical and its possible place in agriculture as a herbicide.

REACTIVITY. Amizol is soluble in water up to 25 percent. It reacts freely with acids and bases forming less active salts. This fact probably is the main reason why Amizol does not produce a prolonged sterility in the soil even at relatively high rates. Being in contact with various bases or acids in the soil, apparently it is quickly converted into less active materials. With many other more complicated compounds, it produces derivatives of specific activity, either on seed or plants. The latter field is hardly touched upon, but the results so far available, are of considerable interest, especially in horticulture.

NON-CORROSIVE. This chemical is expressly systemic and shows no corrosive action on metals generally used in sprayers. When applied to plants it shows no contact injury even to the most susceptible plants. On the contrary, the plants remain turgid and retain normal shape of leaves and stems for several weeks after the chlorophyl has been affected. In general, etiolation of leaves indicates the effect of Amizol. When the foliage is uniformly bleached, it means the chlorophyl is completely destroyed and the death of the plant will follow as surely as after prolonged starvation. On the other hand, if the etiolated leaves and stems show some green, a recovery is likely to occur. This is why the study on rates of various weeds, especially perennials with deep roots, is so important.

NON-POISONOUS. A non-poisonous nature of an agricultural chemical is desirable in all cases. This is especially important with grass killers intended to be used in pastures. Amizol kills certain grasses and during the past three seasons was rather extensively investigated for this purpose. The toxicity studies of Amizol reveal its low toxicity to animals and humans.

WIDE RANGE OF ACTIVITY. Since the herbicidal effectiveness of Amizol is based mainly on its specific action on chlorophyl, it acts on a much wider range of green plant species than any systemic herbicide known. Both monocots and dicots are susceptible to Amizol. Many grasses, broad leaved weeds and woody plants, resistant to phenoxies, are fairly susceptible to Amizol. Yet, it is not a cure all. Certain species in all these groups of plants are resistant, probably due to specific anatomical features protecting their chlorophyl from direct contact or the action of the chemical, or most likely due to the presence of certain enzymes within the plant, which deactivate the chemical against chlorophyl. Wild oats among monocots and sassafras *(Sassafras variifolium)* or grapes among dicots are typical examples.

TRANSLOCATION. With systemic herbicides the rapidity and extent of translocation throughout the plant, together with the durability of its activity within the plant, are of primary importance. If applied at proper rates on vegetatively active plants, Amizol translocates freely throughout the plant's body, including roots. Plants with wide botanical differences such as Canada thistle, Johnson grass and honeysuckle, may be affected and even die if only one part of the plant is exposed to the source of Amizol.

Three weeks after a plot of Canada thistle was foliage sprayed with 8 lbs./A of Amizol, the top soil was removed to a depth of 4 inches. Thirty-six days later some shoots came up on the exposed subsoil. All these shoots were intensely etiolated and eventually died. The same was true of hoary cress and quack grass.

In this connection it is also important to observe that the chemical, once it is absorbed by the plant, remains active for a long time, frequently for two years. Oak and ash sometimes do not show the effects of Amizol at all during the season of treatment. The next year they produce a strongly etiolated foliage and then die. At the same time, its lethal activity in the soil disappears within days or weeks, even at a relatively high rate.

2. Amizol in Controlling Perennial Weeds.

The value of any systemic herbicide for controlling perennial weeds is finally assessed by its two main characteristics: (a) its ability to injure plants and (b) the extent of translocation to the parts which cannot be

directly treated but which have to be destroyed before an effective control may be achieved.

In the light of the experimental evidence now available, Amizol seems to possess both of these essentials. What remains to be known more closely are the best methods, rates, plant species, their stages of growth and also the compatibility of Amizol with other chemicals which all may enhance its effectiveness on various weeds.

This paper is not intended to be a symposium on Amizol. I feel that at this stage the attempt at symposium would be too early. Instead, I will try to refer to some results obtained from carefully planned and recorded experiments.

QUACK GRASS. Amizol was used on Quack grass in comparison with several known grass killers. From the results of these tests it seems safe to state that at equal rates Amizol is equally or more effective on quack grass than any of the other grass killers. Of course, all these chemicals have their own peculiarities and require special conditions for their best performance. Precultivation, for instance, with TCA nearly doubles its effectiveness. The same is true of post cultivation in Amizol treatments. Retreatments, particularly at lower rates, are necessary with all these chemicals, including Amizol. The time of cultivation and retreatments is of great importance.

In 1954, a solid sod of quack grass was treated with 3, 6, 8, 12, 16 and 20 lbs./A of Amizol. The top growth was killed by all these rates. Regrowth, in varying amounts and etiolated to various degrees, also occurred at all rates. Where the treated plots were cultivated three weeks after the treatments and then retreated, when the sprouts began to show over the cultivated areas, the quack grass was so strongly affected by all the rates that the next spring new shoots were intensely purple in color and died soon after emergence.

A crop of barley sown over these plots in 1955 was normal and virtually free of quack grass even at 3 lbs./A rates. On the other hand, in plots treated only once and not cultivated thereafter, some Quack grass was found even at the 20 lbs./A rates.

With slight variation in rates (3 to 15 lbs./A or 4 to 40 lbs./A) similar results were reported from Athabaska, Alberta, and from field work in Pennsylvania.

A *new* approach in the application of Amizol on quack grass was tried in 1955. In one experiment, the first spring growth was treated at the heading stage with 2, 4, 6, 8 and 12 lbs./A. In another case the quack grass hay was cut at full heading, the stubble permitted to sprout about seven inches high and then sprayed also with 2, 4, 6, 8 and 12 lbs./A of Amizol.

The stubble treatments at comparable rates in all cases were *much superior* to those obtained on the original growth at the heading time. Should these results remain as good the next season the stubble treatments may prove to be of great significance in killing quack grass with Amizol.

There is some evidence that Amizol, combined with such propionic compounds as Dalapon, boosts considerably the activity of the combination. In 1955, 2, 4, 6, 8, 12 and 16 lbs./A rates of Amizol and 4 and 8 lbs./A of Dalapon, each alone and in combinations were used. The results were quite consistent in supporting the contention of greater effectiveness of the combinations. When used alone it took 8 lbs./A or more of Amizol and at least 16 lbs./A of Dalapon to kill the top growth of quack grass at the heading stage and prevent resprouting, during the first season. In combination the chemicals gave equally good or even better results with one half of the amount with considerably lower toxicity from Dalapon to the subsequent crop.

In exactly similar experiments with Amizol plus ACP7O5A (2,2,3 - trichloropropionate) the combination was also better than when each of the chemicals used alone, but much weaker and less definite than in the case of Amizol-Dalapon combination. A cultivation of the treated areas seems to be of importance.

CANADA THISTLE. Of the perennial broad leaf persistent weeds, Canada thistle, so far, was best investigated. Much less work was done on perennial Sow thistle. From the results available both these weeds are quite susceptible to Amizol. In treatments involving 1½, 3 and 9 lbs./A rates, at the rosette and bud stages, followed by cultivation and retreatments, both the rosette and the bud stage produced good results. The plots treated at 3 lbs./A or more at the bud stage, with subsequent cultivation and retreatment, practically eliminated the weeds as recorded during the second growing season. Further work is necessary mainly for the purpose of establishing the relative responses according to ecological zones, soil types, best methods, time, and rates of application.

HOARY CRESS. In 1954 and 1955, very extensive treatments have been made with Amizol in dense infestation of Hoary cress. Single treatments at rates from 3 to 16 lbs./A killed the top growth, but permitted considerable regrowth, especially at lower rates. Where the initial treatments with 6 and 12 lbs./A rates were followed by cultivation and retreatment, the weeds were either completely eliminated or only about one percent of badly delayed shoots were recorded the following season. These results were obtained on a heavy clay loam soil. There is some indication that on lighter soils similar results are possible with one application and with no retreatments.

LEAFY SPURGE. This weed, as it is well known, is quite resistant to both cultural and chemical treatments. At advanced rosette, and especially at bud stage, its top growth was slowly but completely killed even at 3 lbs./A rate. Regrowth, both during the season of treatment, and also the next summer, was drastically reduced in terms of initial infestation, but still it was too prevalent to give practical control at 3, and even 6 lbs./A rates. At 16 lbs./A the reduction was up to 98 pct. and gave a fully satisfactory control. These highly significant results were obtained only where the treatments were followed by cultivation three weeks after treatment, and by retreatments when the resprouting over the cultivated areas was well in evidence.

TOAD FLAX. So far, outside of the soil sterilants at high rates and prohibitive cost for extensive areas, no other chemical known is effective enough on Toad flax to offer a practical control. Amizol was extensively used on Toad flax in 1954 and 1955. The study is not completed yet at this time. The results, however, are of considerable interest. First of all they indicate that the Toad flax is quite susceptible to Amizol at the advance rosette stage as well as at the bud stage. The second important information is that it takes much higher rates to control Toad flax than some other perennial weeds. A rate of 6 lbs./A with subsequent cultivation and retreatment was the effective minimum. Higher rates were progressively more effective. Both these rates at the rosette and bud stages gave 93 to 100 and 96 to 100 pct. elimination of the weed, respectively, as recorded in the second season after treatment.

SUMMARY

1. Amizol is a new systemic herbicide acting through the destruction of and interference with the function of the chlorophyl in plants.
2. It is easily soluble in water; readily loses its toxicity in the soil by forming less toxic salts with soil bases and acids; after being absorbed by the plant, retains its activity over a period of two seasons; non-corrosive to metals or plants; it is of low toxicity to animals or humans; it is effective over a wide range of monocotyledonuous and dicotyledonuous species.
3. With respect to perennial persistent weeds it was best investigated on quack grass and Canada thistle. Further work with other perennial weeds is well advised on a broad national scale.

XUM

4. Combination treatments with Amizol and certain propionic acid compounds are definitely more effective than either of the chemicals used alone. Further studies of other combinations are desirable.
5. With quack grass, treatments of stubble resprouted to about seven inches seem to be much more effective than of the original top growth.
6. Post-treatment cultivation, after the top growth is well etiolated and retreatments after regrowth appears over the cultivated areas, seems to be beneficial with all perennial weeds especially on heavy soils.
7. The rapid dissipation of its toxicity in the ground is of special interest to agriculture and places Amizol in a separate class among other herbicides.

[1] American Chemical Paint Company, Saskatoon, Saskatchewan.

CHEMICAL CONTROL OF TEXAS BLUEWEED[1]

A. F. Wiese and H. E. Rea[2]

Control of Texas blueweed (*Helianthus ciliaris*) has not been thoroughly investigated; only a few publications have appeared. Karper (2) published a bulletin on the control of blueweed in 1922. He suggested that 3 moldboard plowings 7 inches deep would effectively control the weed in one season. In 1950, Hamilton (1) showed that 2,4-D ester and amine applied in an oil emulsion at 2 pounds per acre gave good control. Later, Wiese and Rea (3) reported that 60 pounds of CMU gave eradication.

Results

Blueweed control was attempted using both foliage applications and soil treatments. Foliage applications were applied at 1 pound per acre to square rod plots on June 18, 1954 in a triplicated randomized block. The blueweed was in the late bud stage, and the spring had been very favorable for vigorous growth. The ester formulations of the herbicides tested were more effective than the amine formulations. The best control was obtained with 2,4-D ester (propylene glycol butyl ether) which gave 89 percent control with 40 gallons of water per acre as a carrier, 96 percent control with water plus 2 percent wetting agent (Dreft), and 98 percent control when 1 gallon of Diesel oil was emulsified with 39 gallons of water per acre. The 2,4-D acid (emulsifiable) applied in 40 gallons of water per acre plus 2 percent wetting agent or with 160 gallons of water per acre gave 85 and 90 percent control, respectively. MCP ester (propylene glycol butyl ether) with wetting agent and 2-(2,4,5-trichlorophenoxy) propionic acid (propylene glycol butyl ether ester) with wetting agent gave fair control and 2,4,5-T ester (butoxy ethanol) with wetting agent did not decrease the stand significantly below the check.

Because it appeared that the addition of a wetting agent or oil to the carrier increased the effectiveness of 2,4-D ester in the field study, the effect of various carriers was studied in the greenhouse. Blueweed roots were planted in 4-inch pots on November 15, 1954, and on February 17, 1954 the plants were treated with 2 cc. of spray containing 2,4-D ester at the rate of 100, 300 and 600 ppm in various carriers. The experimental design was a split plot with 4 replications. A non-toxic oil (Magnolia S/V 100), Diesel oil and a naptha oil were emulsified at 25 percent of the carrier and a wetting agent (Dreft) was added to water at the rates of 0.05 percent, 0.1 percent and 1.0 percent by weight and compared to water alone as a carrier. All of the oils and the 0.1 percent and 1.0 percent rates of the wetting agent effectively increased the toxicity of the 2,4-D ester to blueweed.

The soil treatments were applied on September 28, 1954, to square rod plots on rangeland in a duplicated randomized block design. Only 10.9 inches of rain fell in the following year. Sodium chlorate at 5, 8 and 13 pounds, and Concentrated Borascu at 16 and 22 pounds per square rod, gave from 96 to 100 percent control. DB Granular (2,4-D and boron complex) at 4 and 6 pounds per square rod gave 85 and 98 percent control, respectively. Silico flouride plus 2,4-D gave 70 percent control. Karmex FW [3-phenyl-1, 1-dimethyl urea] was the most successful urea type herbicide tested, giving complete eradication at ⅜ and ½ pound per square rod. Karmex W [(3-p-chlorophenyl-1-1-dimethylurea)] at ¼, ⅜ and ½ pound per square rod gave 48, 76 and 85 percent control, respectively. Karmex DW [3-(3,4-dichlorophenyl)-1, 1-dimethylurea] was ineffective.

Several phenoxy-type herbicides and a few others were applied in the fall for both their foliage and soil effects at ¼ and ½ pound per square rod. The most successful control was achieved with 2-(2,4,5-trichlorophenoxy) propionic acid (propylene glycol butyl ether ester) which gave 98 percent control without hurting the perennial grasses. The ester (propylene glycol butyl ether) and amine (ethanol and isopropyl) formulations of 2,4-D also gave good control, but 2,4-D acid (emulsifiable), 2,4,5-T ester (tetrahydrofurfuryl), and SES gave mediocre results. Amino triazole did not significantly reduce the weed stand as compared to the check.

Summary

Excellent control of blueweed was obtained with foliage applications of 2,4-D ester at 1 pound per acre applied in water plus 2 percent wetting agent or 1 gallon of Diesel oil emulsified with 39 gallons of water per acre.

A wetting agent or oil emulsified in a water carrier significantly improved the toxicity of 2,4-D ester to blueweed in greenhouse studies.

Soil treatments and rates per square rod that gave 96 percent or more control in one year were Concentated Borascu at 16 and 22 pounds, sodium chlorate at 5 and 8 pounds, Polybor Chlorate at 10 and 15 pounds, Atlacide at 5, 8 and 13 pounds, DB Granular at 6 pounds, 2-(2,4,5-trichlorophenoxy) propionic acid (ester) at ½ pound and Karmex FW at ⅜ and ½ pounds.

Literature Cited

1. Hamilton, Roger D. The effect of various 2,4-D and 2,4,5-T formulations and carriers on the control of blueweed (*Helianthus ciliaris*) in a perennial grass mixture. Res. Rept. Seventh Annual N.C. Weed Control Conf. p. 35. 1950.
2. Karper, R. E. The blueweed and its eradication. Texas Agr. Exp. Sta. Bul. 292. 1922.
3. Wiese, A. F. and Rea, H. E. Control of blueweed (*Helianthus ciliaris*) with CMU and 2,4-D. Res. Rept. Tenth Annual N. C. Weed Control Conf. p. 35. 1953.

[1] Contribution of the Amarillo Experiment Station, U.S.D.A. and Texas Agricultural Experiment Station Cooperating. Approved as T.A.E.S. T.A. 2281.

[2] Assistant Agronomist at Bushland, Texas, and Associate Professor at College Station, Texas, respectively.

CHEMICAL CONTROL OF JOHNSONGRASS

L. E. Anderson[1]

Johnsongrass is rapidly becoming one of the most troublesome weed species in Kansas. Once thought to be adapted only to southern areas it is now widely distributed in the southeast portion and in the western irrigated sections of the state. In fact, Johnsongrass has spread at such an alarming rate that at present 56 counties in the state have declared it a noxious weed. This is encouraging from the standpoint of control since it is an indication that authorities in those counties have recognized the seriousness of the situation and are determined to do something about it.

XUM

Naturally farmers are interested in learning how to control this persistent invader. Numerous requests for information—particularly on the use of chemicals—coming from many areas in the state prompted the study we are about to describe. In planning the study, it was decided to observe the performance of various chemicals available in the soil sterilant category in addition to herbicides used in foliar applications. Consequently two uniformly infested bottom land sites were selected; one on which soil sterilants were to be used, and the other on which foliar applications were to be made. After the dried vegetation had been removed by burning, the two areas were staked in square rod plots.

The soil sterilant applications were made on April 15 and 16, at which time no Johnsongrass shoots had emerged. Following are the chemicals together with the rates that were applied in three randomized replications: TCA, 40, 80, 120 lbs./A; CMU, 30, 60, 90 lbs./A; PDU, 30, 60, 90 lbs./A; NaC103, 4, 6, 8 lbs./sq. rd.; PbC1, 4, 8, 12 lbs./sq. rd.; Borascu, 4, 8, 12 lbs./sq. rd.; Chlorea 3, 6, 12 lbs./sq. rd.; Baron, 1.0, 1.5, 2.0 pts./sq. rd.; DB Granular, 3, 6, 12 lbs./sq. rd.; and Ureabor, 2, 4, 8 lbs./sq. rd. Of these chemicals CMU and PDU at rates of 90 lbs./acre were comparable in effectiveness to sodium chlorate and Ureabor at 8 lbs./sq. rd. Polybor chlorate at 12 lb./sq. rd.; and Chlorea at 6 lbs./sq. rd. gave good control. Eighty pounds of TCA killed 95% of the old plants but a dense growth of seedlings appeared after a period of ten weeks. Effectiveness of the various treatments was determined by harvesting two-four foot quadrats from each plot at the end of the growing season. The weight of these air-dried samples was the basis upon which comparisons were made.

Foliar applications were made on May 20 and 21 when the Johnsongrass plants were from 12 to 15 inches tall. With the exception of HCA which was applied in diesel fuel at one-half gallon per square rod, the materials were applied in a water carrier at the same volume. A sticker was used with all applications. Following are the chemicals and rates used in this phase of the experiment: Baron, 1.0, 1.5, 2.0 pts./sq. rd.; 2, 2, 3-Trichloropropionate, sodium salt, 10, 20, 40 lbs./A; Hexachloro Acetone (98%) ¼, ½, 1 pt./sq. rd.; Amino Triazole, 2, 4, 8 lbs./A.; Maleic Hyrazide, 4, 8, 16 lbs./A.; Dalapon (85%) 10, 21, 40 lbs./A.; 2,4-D (butyl ether ester) 40, 80, 160 lbs./A.; Dalapon combined with Amino Triazole at half the above rates; and 2, 2, 3-Trichloropropionate combined with Amino Triazole at half rates for each. Among these herbicides that gave excellent results were Baron at all rates, Dalapon and 2, 2, 3-Trichloropropionate at 20 and 40 lbs./A. Hexachloro Acetone gave satisfactory control where one pt. per sq. rd. was applied. The applications of Amino Triazole and Maleic Hydrazide resulted in growth inhibition for a limited period but recovery was evident at a later date. Heavy rates of 2,4-D destroyed all top growth but the effects were temporary except for the 160 lb. rate where regrowth was stunted and seed reduction was evident. The addition of Amino Triazole to 2, 2, 3-Trichloropropionate or Dalapon did not appear to alter the effects of those materials. Of the herbicides applied to the foliage in this phase of the study the new formulation, Baron, was of interest because it appeared very promising when used as a foliar spray but gave unsatisfactory control when applied directly to the soil.

[1] Kansas Agricultural Experiment Station, Manhattan, Kansas.

THE INFLUENCE OF NITROGEN FERTILIZATION ON THE CONTROL OF QUACKGRASS WITH HERBICIDES

W. H. Zick and K. P. Buchholtz[1]

Research aimed at determining the influence of soil fertility upon the action and effectiveness of herbicides has been very limited. The fertility level of the soil, especially the nitrogen level, can greatly affect the amount of foliage produced on a given area. Nitrate fertilization in the late fall or early spring normally results in the production of more foilage and at an earlier date. This is especially true in the case of perennial grasses.

When considering the effectiveness of a foliage application of an herbicide, the amount of foliar surface available to absorb the herbicide becomes an important factor. Thus, when working with a perennial weed such as quackgrass, which has an enormous supply of dormant buds on its rhizomes, the stimulation of more of these buds to produce shoots will increase the leaf surface available to intercept the herbicide. This will not only increase the efficiency of a given unit of the herbicide but will also reduce the possibility of dormant rhizome material escaping the treatment.

Several experiments were conducted during 1954 and 1955 at Madison and at the Ashland Experiment Station to determine the influence of nitrogen fertilization upon the effectiveness of three chemicals in controlling quackgrass. One experiment was conducted at Madison on land which had a low level of nitrogen and a dense, uniform stand of quackgrass. The experiment was set up in a split-plot design with nitrogen treatments as the whole plots. Each treatment was replicated four times. All nitrogen was applied as ammonium nitrate. The nitrogen treatments were as follows: (1) No N, (2) 75 lb. N applied in fall, (3) 75 lb. N applied in early spring, (4) 75 lb. N in fall plus 75 lb. N in spring, and (5) 150 lb. N applied in early spring.

On April 27, 1955, the following applications of herbicides were made within each nitrogen level: 4 lb./A maleic hydrazide (1,2-dihydropyridazine-3, 6-dione), 4 lb./A. dalapon (2, 2-dichloropropionic acid), and 4 lb./A. amino triazole (3-amino-1,2,4-triazole). At the time of these applications the quackgrass foliage on plots receiving nitrogen in the spring was between 6 and 8 inches of height. The plots which received the nitrogen in the fall had slightly less foliage, and the plots which received no nitrogen had less than ½ as much foliage as those receiving the nitrogen in the spring. This foliage was both shorter and more sparse. The entire area was plowed with a sod-bottom plow on May 2, 1955, five days after the application of the herbicides. The area was given a broadcast application of 400 lb./A. of a 12-12-12 fertilizer and was fitted for planting. It was planted to Wisconsin 575 field corn on May 16, 1955. Two days after planting the corn the area was given a soil treatment of 1.5 lb./A. of CMU, which gave nearly complete control of the annual weeds throughout the entire growing season.

To estimate the reduction in the infestation of quackgrass obtained by these various treatments, shoot counts were made on June 7, 1955. To estimate the over-all effect of the various treatments upon the corn, the ripe ear corn was harvested on September 22, 1955, and yields were obtained. The data on shoot counts and corn yields from the nitrogen treatments and over all chemical treatments are summarized and presented in Table I. There was no significant interaction between nitrogen treatments and chemical treatments, so this overall comparison is valid. Duncan's new multiple range test was applied to the data. Significance with this test is indicated by placing a line adjacent to all

values which are not significantly different. Thus, all values not adjacent to the same line are significantly different.

Table I

Quackgrass shoot counts and corn yields from plots receiving five N treatments over all four chemical treatments.

N application lb./A.	Shoots per sq. ft.	Corn yields bu./A.
None	16.8	54.5
75—Fall	12.8	61.9
75—Spring	11.5	72.5
75—F plus 75—S	9.6	70.6
150—Spring	8.4	72.7

The shoot count data show that there was no difference of significance between the two 150 lb./A. nitrogen treatments. However, all the other nitrogen treatments were significantly different from each other. There were at least two factors confounded and working together in this shoot count data. First of all, as the application of nitrogen increased many of the dormant buds were stimulated to produce shoots early in the spring and prior to the chemical applications and the plowing. This left fewer dormant buds remaining which could be activated to produce shoots after the foliage was plowed under. Secondly, the activation of dormant buds and the stimulation of shoot growth by the nitrogen in the early spring gave a substantial increase in the foliar surface available for intercepting and absorbing the chemicals. Thus the amount of chemical actually taken into the quackgrass plant was increased, resulting in a greater relative efficiency of the chemicals and subsequently in a reduction in the number of buds which could be activated to produce shoots following plowing.

Although it is impossible to separate the effects of these factors, it seems logical that the increase in foliage surface by the nitrogen with subsequent increase in the relative efficiency of the chemical was the more important factor.

The corn yield data show that all the spring applications of nitrogen resulted in an increased yield over that of the check. However, here, too, the increase in corn yield due to a reduction in competition from quackgrass was confounded with the fertilizer effect of the nitrogen and with the residual effect, if any, of the chemicals on the corn. The pre-corn planting application of fertilizer should have reduced the fertilizer effect of the early nitrogen application to a negligible level, so that factor can probably be eliminated.

The data on shoot counts and corn yields from the chemical treatments and over all levels of nitrogen are summarized and presented in Table II.

Table II.

Quackgrass shoot counts and corn yields from plots receiving four chemical treatments over all five N treatments.

Chemical application lb./A.	Shoots per sq. ft.	Corn yields bu./A.
Dalapon—4	3.9	82.3
MH—4	5.4	74.5
ATA—4	10.6	72.6
Check	27.5	36.4

From the shoot count data it is apparent that for inhibiting the production of quackgrass shoots the chemicals rank in the following order from most effective to least effective: 1. Dalapon, 2. Maleic hydrazide (MH), and 3. Amino triazole (ATA). The untreated check gave shoot counts significantly higher than did any of the chemical treatments. In fact, the shoot counts from all treatments are significantly different from one another. The corn yields again show a trend which is just opposite to that of the shoot counts. As the shoot counts increase, indicating increased competition from the quackgrass, the corn yields decrease. All chemicals gave a significant increase in yields of corn over that of check. Plots treated with amino triazole gave yields of corn significantly lower than those treated with dalapon but almost equal to those treated with maleic hydrazide. Some typical dalapon injury was noticed in the early growth of the corn, but, as the yields indicate, no permanent injury of consequence resulted. Both the shoot count data and the corn yield data presented in Table II are exceptionally good estimates of the reduction in the quackgrass infestation by these chemicals since each value presented is the average of 20 replicates, four within each of five levels of nitrogen.

A ranking of the quackgrass infestations was made on all plots of this experiment on October 19, 1955. The visible quackgrass infestations at this time gave unqualified support to the results obtained in the analysis of the shoot count and corn yield data.

Another experiment was conducted at the Ashland Experiment Station. This experiment involved an application of nitrogen as ammonium nitrate on September 4, 1954, and applications of dalapon, amino triazole and maleic hydrazide, each at 5 lb./A. on September 22, 1954, followed by plowing after 34 days. Quackgrass shoots were counted on June 7, 1955. The shoot count data are summarized and presented in Table III.

Table III.

Ave. number of quackgrass shoots per sq. ft. from plots receiving two N treatments within four chemical treatments.

	Chemicals			
65 lb. N/A.	ATA	MH	Dal	Check
Plus	15.0	12.7	10.3	29.1
Minus	17.9	22.9	16.7	42.8

This shows that the nitrogen alone causes a significant reduction in the shoot counts. It also shows that the nitrogen causes a greater reduction in shoot counts when in combination with maleic hydrazide than with dalapon or amino triazole. This may only hold true when the period between the application of the maleic hydrazide and the cultural treatment is relatively long, as it was in this experiment.

Another experiment was conducted at Madison in the spring of 1955 to determine the influence of fertilization with nitrogen upon the action of maleic hydrazide in inhibiting the development of buds of quackgrass rhizomes. An old alfalfa field heavily infested with quackgrass and low in available nitrogen was selected for the experimental area. On April 1, 1955, when the soil was still frozen, the area was burned over, four 18 by 50 foot plots were laid out, and ammonium nitrate was applied to two of these plots at the rate of 65 lb./A.N. On April 26 one of each of the plus nitrogen and minus nitrogen plots was treated with maleic hydrazide at 8 lb./A. The quackgrass foliage on plus nitrogen plots was 6 inches tall at this time while on the minus nitrogen plots it was only 4 inches tall. Rhizome samples were taken at varying intervals throughout the months of April and May. The rhizomes were dug from three or more locations within each plot. These three samples were bulked, washed thoroughly in cold water, and the healthy rhizomes were selected and cut into segments so that each segment included three buds. Three 15 gram samples of these segments were weighed out for each treatment on every sampling date. The total number of buds in a given sample was obtained and recorded. The rhizomes were then planted in pots and placed in the greenhouse. Four weeks after planting each respective series, the shoots which had emerged from each pot were counted and recorded. The percentages of the buds producing shoots were calculated and are summarized and presented in Table IV.

XUM

Table IV.

Percent of quackgrass rhizome buds which, having been obtained at different dates from plots receiving respective treatments of nitrogen on April 1, 1955, and of MH on April 26, 1955, produced emerged shoots within four weeks of growth.

	Minus MH		Plus MH	
Sample Date	Minus N	Plus N	Minus N	Plus N
April 1	33.0	——	——	—
			(65 lb./A. N applied)	
April 15	39.5	36.5	——	—
April 22	38.4	36.6	——	—
			(8 lb./A. MH applied)	
April 29	37.3	33.9	4.3	6.6
May 3	30.0	29.8	4.4	5.2
May 11	29.0	23.6	10.0	0.1
May 25	19.0	24.5	29.1	6.3

Both the rhizome buds obtained from plots receiving nitrogen and those from plots receiving no nitrogen were relatively active in producing emerged shoots during the month of April. However, in early May there was a considerable drop in this activity. The rhizome buds from the area receiving the nitrogen showed slightly less activity than those from the area receiving no nitrogen.

Three days after the maleic hydrazide was applied the per cent of buds of rhizomes from treated plots which produced emerged shoots dropped sharply. In the plus MH—Minus N treatment this reduction held through six days after the maleic hydrazide application, but then a gradual increase in the bud activity began and by May 25 a stimulation was shown. The rhizomes from the area receiving the plus MH—plus N treatment maintained a low level of bud activity throughout the month of May.

Conclusions

1. The nitrogen stimulates the quackgrass rhizome buds so that more shoots per unit area are produced. This together with an increase in the size of each leaf gives a greater foliar surface for interception and absorption of the chemicals. Thus the relative efficiency of each chemical is increased.
2. The nitrogen, especially nitrate nitrogen, initiates foliar growth earlier so that a herbicide application can be made earlier. This can become of practical importance if a waiting period is necessary for decomposition of a chemical before a subsequent crop can be planted.
3. The nitrogen prolongs the rhizome bud inhibitory effect of maleic hydrazide. This can be a practical advantage to the farmer, since it makes less critical the period of time following the foliar application of MH in which he can apply the supplementary cultural treatment of plowing or cultivation and still obtain good control of quackgrass.
4. The early spring applications of nitrogen seem to be more effective than the late fall application.
5. Much of the nitrogen is absorbed by the quackgrass tissue and will become available to a subsequent crop upon decomposition of that tissue. Thus, much of the cost of such a nitrogen application can be charged to fertilizer.
6. In these experiments the three chemicals ranked in the following order in their effectiveness in controlling quackgrass: 1. Dalapon, 2. Maleic hydrazide, 3. Amino triazole.

[1] Res. Asst. and Prof. of Agronomy, respectively, Department of Agronomy, University of Wisconsin. Supported in part by an industrial grant from the Dow Chemical Company, Midland, Michigan.

COMPETITION, CULTIVATION AND CHEMICALS TO ELIMINATE LEAFY SPURGE

(A Summary of Five Years of Research)

Lyle A. Derscheid, Keith E. Wallace and Russell L. Nash[1]

Introduction

The use of chemicals for the control of leafy spurge was tested for several years. By 1950 it became apparent that the chemicals available at that time were not practical for the elimination of large infestations. Consequently 30 acres of spurge infested land were leased for the purpose of studying methods of eliminating this noxious weed.

One-third of the farm was divided into plots in 1950, a second third was divided in 1951 and the remainder in 1952. Each year, two 3-year studies were initiated. One study involved the use of bromegrass, cultivation and 2,4-D with treatments to be applied each of three years. Identical experiments in this investigation were initiated in August, 1950, 1951 and 1952. The last experiment is completed but final weed counts will not be made until 1956.

A second 3-year study involved the use of annual crops (rye, sudan grass, buckwheat and oats), cultivation and 2,4-D. Here again identical experiments were initiated in August, 1950, 1951 and 1953 with final weed counts on the last one, are to be made in 1956.

Three experiments including the use of several soil sterilants applied at several rates during July and September were conducted. After the results of each experiment were obtained, the area was seeded to a crop to determine the length of residual toxicity. Numerous experiments designed to test new chemicals and new formulations of old chemicals were conducted.

Since complete results have not been obtained on the 3-year experiments, this paper will serve as a progress report with each experiment or series of experiments being reported in abstract form.

Perennial Forage Crops, Cultivation and 2,4-D

One experiment was started during the fall of 1950, another identical experiment was started during the fall of 1951 and a third in 1952. In each experiment 44 treatments were applied to two replications of 1-rd. x 5-rd. plots. In the 1950 experiment, 32 treatments included the seeding of bromegrass during August of that year—eight of these treatments included the applications of 2,4-D ester in 1951, eight were treated in 1952, eight were treated in 1951 and 1952 and eight were treated in 1951 and 1953. In each set of 8,2,4-D was applied at rates of ½ and 1 lb./acid equiv. per A. in (1) May, (2) summer when upper bracts turn yellow, (3) September and (4) May and September. Consequently, some plots received one 2,4-D application, some received two treatments and others received four. Three of the remaining 12 treatments consisted of (1) alfalfa, (2) bromegrass, and (3) alfalfa-bromegrass mixed—they were not sprayed. The remaining nine treatments consisted of intensive cultivation at two-week intervals from May 15 to August 15 in 1951, when they were seeded to bromegrass. One plot was not sprayed, but the remaining eight were sprayed with ½ or 1 lb./A. of 2,4-D ester in (1) May, (2) summer, (3) September and (4) May and September during 1951. One-half of each plot was fertilized with 120 lb./A. of ammonium nitrate (34.5% N) in 1953. The experiments started in 1951 and 1952 have been handled in the same manner except that fertilizer was applied during the 2nd and 3rd year of the experiment instead of just the 3rd year.

The experiments started in 1950 and 1951 were completed in 1953 and 1954 and final count of weeds were made on two square-yard areas in each half of each plot the following May. The results on these two experiments

were very similar. The mean for the 1950 experiment was 74% elimination, while the mean for the second experiment was 70%. Therefore, these two experiments are essentially the same as one experiment of four replicates. Fertilizer did not improve the competitiveness of bromegrass enough to kill leafy spurge as the means for fertilized and unfertilized were 74 and 71 per cent, respectively. The rate of application of 2,4-D made little difference as the mean of ½ lb./A. was 70% elimination compared to 75% for the 1 lb./A. rate. Likewise date of application was unimportant as the percentages of elimination were 71 for spring treatments, 71 for early summer treatment, 71 for late summer and 76 for two treatments in spring and late summer. However, two treatments a year were slightly better than one treatment.

The only treatments that were satisfactory were those that included cultivation at two-week intervals from June 1 to August 15, and were seeded to bromegrass which gave 95% elimination. The use of 2,4-D at rates of ½ or 1 pound per acre the following year did not give any additional elimination. Even though these plots were cultivated one entire season,, they produced as much hay as those that produced three crops. The percentage of weeds eliminated are given in Table 1.

Table 1.

The Percentage of Weeds Eliminated When Perennial Forage Crops, Cultivation and 2,4-D are Used to Control Leafy Spurge

Treatments in Bromegrass	Percentage of Elimination: One-half pound per acre					One pound per acre				
	Spr.	Sum.	F.	Spr. & F.	Mean	Spr.	Sum.	F.	Spr. & F.	Mean
2,4-D 1st year	64	67	61	64	63	69	73	63	67	68
2,4-D 2nd year	57	57	56	58	57	56	62	66	68	63
2,4-D 1st & 2nd years	70	64	63	61	67	68	66	68	75	69
2,4-D 1st & 3rd years	62	61	73	78	79	78	76	80	87	80
Cult. 1st year, 2,4-D 2nd year	91	94	87	93	91	91	92	99	96	94
Cult. 1st year, No 2,4-D	—	—	—	—	—	—	—	—	—	95
Mean of 2,4-D treated	69	69	68	73	70	74	74	74	78	75

Annual Crops, Cultivation and 2,4-D

Identical experiments were started during the falls of 1950, 1951, and 1952. In each case 33 treatments were applied to two replications of 1-rd. x 5-rd. plots. For the experiment started in 1950, one treatment consisted of intensive cultivation for two years at two-week intervals followed by a crop of sudan grass; a second treatment was the same except that cultivations were conducted at three-week intervals. One pair of plots (1 plot in each replication) raised 1 crop of rye and 2 crops of buckwheat, while sudan grass was substituted for the buckwheat in a fourth treatment.

A fifth treatment was the regular rye-fallow system for two years followed by one year of intensive cultivation. In eight treatments rye was used two years followed by 1 of buckwheat, eight had two years of rye and one of sudan grass, and eight had two years of rye and one of oats. Four treatments of each set of eight included spraying 1st year and four were sprayed the 1st and 2nd years. In each group of four, the spraying treatments consisted of (1) 1 lb./A. of ester in grain, (2) 1 lb./A. of ester in stubble after harvest, (3) 1 lb./A. of ester in grain and 1 lb./A. in stubble and (4) ½ lb./A. of ester in grain and 1 lb./A. in stubble. The plots sprayed the second year all received 1 lb./A. in the stubble. The remaining four treatments included rye sprayed with the above four treatments the first year and oats sprayed with ½ lb./A. the 2nd year. The 3rd year was unsprayed oats. Final weed counts were taken from four-square-yard areas on each plot in May, 1954. The experiments started in 1951 and 1952 were handled in the same manner.

The three experiments were completed in 1953, 1954 and 1955 with final weed counts being made the following spring. Consequently final counts have been made on only two experiments. These data indicate that the results of the two experiments were very similar. The average percentage of weed elimination was 87 for one experiment and 93 for the second one. Therefore, these two experiments are essentially the same as one experiment with four replicates. Intensive cultivation gave 99% elimination in less than two years. It made little difference whether the interval between cultivation was two or three weeks.

Sudan grass was the best competitive crop used. One crop of sudan was capable of reducing the stand of leafy spurge 54%, while a crop of buckwheat reduced it 50%, a crop of oats sprayed with one-half pound of 2,4-D ester per acre reduced it 40% and a crop of unsprayed oats increased it 4 to 5%. Three years of rye and cultivation eliminated 32% of the weeds.

The most effective use of 2,4-D was made by spraying with one-half pound in the grain and one pound in the stubble. Two years of this reduced the stand of leafy spurge by 83%. A competitive crop of sudan grass or buckwheat following such treatment did not reduce the remaining stand materially. The use of 2,4-D on rye just before the boot stage of growth did not materially decrease yield. The mean yields of untreated rye, rye treated with one-half pound per acre and one pound per acre were 16.6, 13.5, 13.2 bushels per acre respectively.

Soil Sterilants for Patches

Duplicate 9-ft. x 15-ft. plots were treated in September, 1952 and July, 1953 with Borascu at 10, 15 & 20 lb./sq. rd., Concentrated borascu, Polybor, Polyborchlorate and Chlorax at 5, 7½, and 10 lb./sq. rd., sodium chlorate at 3 and 5 lb./sq. rd., Ammate at 2, 4 and 6 lb./sq. rd., and CMU at 1, 2, 3, and 4 oz./sq. rd. A similar experiment had been applied during the fall of 1950 and in July 1951.

In 1954 Borascu at 15 and 20 lb./sq. rd.; Concentrated borascu, Polybor, Polybor chlorate and Chlorax each at 8 and 10 lb./sq. rd.; sodium chlorate at 4 and 5 lb./sq. rd.; Ammate at 5 and 7½ lb./sq. rd.; and DB Granular and DB Spray at 2½, 5 and 7½ lb./sq. rd. in July. By September 1, Polybor, Polybor-chlorate, Chlorax, Ammate, DB Spray and DB Granular had given good top kill. In late September a second set of plots were treated with the same chemicals at the same rates except that Karmex DW and Karmex FW at 0.3 & 0.5 lb./sq. rd. were also included.

The results show that the following treatments generally kill 95% to 99% of the leafy spurge: Conc. borascu 10 lb./sq. rd., Polybor 10 lb./sq. rd., chlorate of soda 5 lb./sq. rd., borate-chlorate mixtures (Chlorax or Polybor-chlorate) 10 lb./sq. rd., Ammate 5 lb./sq. rd. and borate-2,4-D mixtures (DB Spray and DB Granular) at 5 lb./sq. rd., when applied in the fall. The compounds containing chlorate or Ammate were not as dependable in July. CMU at rates of ½ lb./sq. rd. or less was not satisfactory.

At these rates bromegrass sod was injured the least by DB-Granular, followed by Conc. borascu, Polybor, and Ammate. The borate-chlorate mixtures, chlorate, CMU and DB Spray killed practically all of the grass. Ammate and DB Spray give the quickest top kill followed in order by DB Granular, sodium chlorate, Polybor-chlorate and Chlorax, Polybor, Concentrated borascu and Borascu.

The plots treated in 1950 and 1951 were seeded to rye in 1954 and to oats in 1955. Plots treated in July 1951 with Polybor or Polybor-chlorate at rates of 12 and 16 pounds per square rod or with concentrated borascu at 10 and 15 pounds per square rod or with Borascu at 20 pounds per square rod did not produce a crop either year, although Russian thistles and kochia grew on all plots. Likewise, small grain did not grow on any of the CMU plots. There was enough chemical left in the soil after almost three years to kill the oats. The toxic effect of sodium chlorate remained until 1954 (almost

XUM

two years) but was apparently gone before 1955. The residual effect of Ammate was gone after one year.

These results contrast with those of plots treated in September 1952 and July 1953 as the residual effect had worn off of all the later plots except those treated with CMU. It is possible that the difference in results in the two experiments is due to the fact that the 1951 experiment is on low land that is poorly drained. Consequently, the chemical is not leached below the root zone of the crop. The later treatments are on higher land that has better drainage and leaches the chemical down beyond the root zone of crops.

New Chemicals and High Rates of 2,4-D

Twenty-eight treatments were applied in 1954 to two replications of 1-rd. x 4-rd. plots seeded to bromegrass in 1953. 2,4-D amine was applied in 11 treatments; (1) 20 lb./A. spring, 0 lb./A. in fall; (2) 30 in spring, 0 in fall; (3) 40 in spring, 0 in fall; (4) 0 in spring, 20 in fall; (5) 0 in spring, 30 in fall; (6) 0 in spring, 40 in fall; (7) 10 in spring, 10 in fall; (8) 10 in spring, 20 in fall; (9) 10 in spring, 30 in fall; (10) 20 in spring, 10 in fall; (11) 20 in spring, 20 in fall. An amine of 2,4-5 trichlorophenoxypropionic acid (silvex) was applied in 12 treatments: (1) 20 lb./A. in spring, 0 lb./A in fall; (2) 30 in spring, 0 in fall; (3) 40 in spring, 0 in fall; (4) 0 in spring, 20 in fall; (5) 0 in spring, 30 in fall; (6) 0 in spring, 40 in fall; (7) 10 in spring, 10 in fall; (8) 10 in spring, 20 in fall; (9) 10 in spring, 30 in fall; (10) 20 in spring, 10 in fall; (11) 20 in spring, 20 in fall; (12) 10 in spring, 0 in fall. 3-amino 1,2,4 triazole was applied in spring at 2, 4, 8 and 16 lb./A. The silvex and 2,4-D were applied in 10 gallons of spray per acre, while amizol was applied in 40 gal./A.

Plant counts on 4 sq. yds. of each plot on May 14, 1955, revealed that all silvex treatments had killed 93 to 99% of the spurge with little injury to the bromegrass. Amizol at rates of 2 and 4 lb./A. eliminated 74 and 58% of the spurge, but the rates of 8 and 16 lb./A. gave a 99% kill. All rates of amizol injured the bromegrass with the higher rates reducing the stand over 75%. The best 2,4-D treatment was the 40 lb./A. rate applied in September—it eliminated 75% of the leafy spurge and reduced the stand of bromegrass by 25%. These preliminary results indicate that amizol may be used like a soil sterilant to eliminate leafy spurge and that heavy rates of silvex may be more reliable than heavy rates of 2,4-D.

New Formulations of 2,4-D

Ninty treatments were applied in 1954 to three replications of 1-rd. x 4-rd. plots seeded to bromegrass in 1953. Five chemicals (a butoxyethanol ester of 2,4-D, an emulsifiable acid with a translocator added, a butoxyethanol ester of parachloro with a translocator added, a butoxyethanol ester of 2,4-D with translocator added and butoxyethanol ester of MCP with translocator added) were applied in 17 treatments 7 in 10 gal. of spray per acre, 7 in 40 gal. of water per acre and 3 in 80 gal. of water per acre. One-half lb./A. was applied in May to 4 plots sprayed with 10 gal./A. and 4 plots sprayed with 40 gal./A. while 1 lb./A. was applied to 3 plots for each of the 3 volumes. In September the ½ lb./A. plots were retreated with 0, ½, 1 and 2 lb./A. rates in same vol./A. as used in the spring, while the 1 lb./A. plots were treated with 0, 1 and 2 lb./A. in same vol./A.

On May 14, 1955, leafy spurge counts were made on four sq. yds. of each plot to determine the percentage of kill. The 2,4-D formulations were much superior to other chemicals and there was no difference among volume of spray solution per acre. The best kill was obtained on plots treated in May and again in September —there was little difference among rates of application, however, the plots treated with 1 lb./A. in May averaged about 5% better kill than plots treated with ½ lb./A. The butoxyethanol ester with a translocator added averaged about 15% better than the emulsified acid with a translocator added and about 25% better than the butoxyethanol ester without the additive. The best kills were between 85% and 90%.

Twenty-four of the best treatments (8 of each 2,4-D formulation) were applied to leafy spurge growing in Mo-0-205 oats in 1955. Spring treatments of ½ lb./A. and 1 lb./A. were applied June 2, when oats were starting to head. Fall applications of ½, 1, and 2 lb./A. were applied in the stubble. Oat yields were between 50 and 60 bu./A. indicating that neither rate (½ or 1 lb./A.) of either chemical reduced the yield of the crop. These results indicate that 2,4-D is superior to similar formulations of MCP and para and that better kills of leafy spurge may be obtained if some way is devised (perhaps the addition of a translocator compound) to get the 2,4-D translocated to the roots.

[1] South Dakota State College, College Station, South Dakota.

EFFECT OF SOIL STERILANTS ON THE WIND ERODIBILITY OF PULLMAN SILTY CLAY LOAM[1]

A. F. Wiese and H. E. Rea[2]

During the winter of 1953-54, serious wind erosion occurred near Bushland, Texas, on Pullman silty clay loam soil which had been previously treated with soil sterilants for bindweed eradication. Because of the seriousness of wind erosion in the southwestern United States, preliminary studies were conducted to determine if soil sterilants, methods of soil sterilant application or tillage after sterilization had any bearing on wind erodibilty.

Revew of Literature

The wind erodibility of a soil depends upon both climate and conditions at the soil surface, according to Chepil, Woodruff and Zingg (2). Wind erosion is usually associated with low rainfall and high wind. The conditions at the soil surface that determine erodibility are soil cloddiness, mechanical stability of the clods, surface roughness and crop residues. In general, a loamy sand soil is 8 times as erodible as a sandy loam and 40 times as erodible as finer-textured soils (2).

The erodibility of a soil can be estimated by using the formula $X = 3302 \frac{10\,I}{(RK)^{1.41}}$ as shown in Chepil, Woodruff and Zingg (2). Where X is estimated soil loss in tons per acre, 10 I is a factor determined from the percent by weight of soil particles less than 0.84 mm in size, R is the surface residue in pounds per acre and K is the ridge roughness in inches.

The Pullman silty clay loam soil on which this experiment was conducted is fine textured, containing 29 percent sand, 52 percent silt and 19 percent clay in the top 1.5 inches of soil (3).

Methods and Materials

This study consisted of two field experiments, one on dryland and another under irrigation. The dryland experiment was a split-split-plot with 3 replications. The sub-sub-treatments applied in September 1953 were (1) no treatment, (2) Concentrated Borascu at 18 pounds per square rod, (3) Polybor Chlorate at 10 pounds per square rod, (4) Sodium chlorate at 6 pounds per square rod and (5) CMU at ¼ pound per square rod. The sub-treatments were (1) no treatment, (2) two diskings after chemical application and (3) a watering of 0.12 inch after chemical application. The two major treatments consisted of subsurfaced tillage and sorghum planting in June 1954 versus no tillage and no sorghum.

The irrigated experiment was a randomized block with 3 replications. The treatments applied in September 1953 were (1) no treatment, (2) Concentrated Borascu at

XUM

18 pounds per square rod, (3) sodium chlorate at 6 pounds per square rod, (4) Polybor Chlorate at 10 pounds per square rod, (5) CMU at ¼ pound per square rod and (6) CMU at ½ pound per square rod. This experiment received two 2-inch irrigations in the summer of 1954 and three more 2-inch irrigations in the summer of 1954 in addition to 21 inches of rainfall from September 1953 through February 1955. No sorghum was planted on this experiment.

During February 1955, the surface soil from the two experiments was sampled for aggregate analysis by bulking four samples 1 inch deep from each square rod plot. The wind erodibility of soils treated with soil sterilants was estimated from results obtained by sieving samples of soil in a rotary sieve designed by Chepil (1) to determine the percent aggregates greater than 0.84 mm in size and the mechanical stability of the aggregates.

Results

In the dryland experiment Concentrated Borascu, Polybor Chlorate and sodium chlorate applied at 18, 10 and 6 pounds per square rod, respectively, increased the percent of aggregates larger than 0.84 mm and the mechanical stability of the aggregates over the check (Table 1). Analysis of the data also indicated that the average percent of particles larger than 0.84 was significantly decreased where the sterilants had been disked into the soil immediately after application. Tillage of the treated soil with a sweep plow followed by sorghum planting significantly increased mechanical stability of the aggregates during the winter of 1955.

Table 1. Percent aggregates larger than 0.84 mm and aggregate mechanical stability from dryland soil previously treated with soil sterilants.

Soil sterilant	Rate per sq. rod (lbs.)	Aggregates >0.84 mm (%)	Mechanical stability (%)
Check	0.0	50.5	71.6
Concentrated Borascu	18.0	68.8**	81.2**
Polybor Chlorate	10.0	57.4**	77.2**
Sodium Chlorate	6.0	58.5**	76.6**
CMU	0.25	49.0	72.1
LSD .05		3.3	2.2
LSD .01		4.5	2.9

** Significantly greater than the check at the 1 percent level.

In the irrigated experiment all sterilants except Concentrated Borascu significantly reduced the percentage of aggregates larger than 0.84 mm. The mechanical stability of all treatments was the same as the check (Table 2).

Table 2. Percent aggregates larger than 0.84 mm and mechanical stability from irrigated soil previously treated with soil sterilants.

Soil sterilant	Rate per sq. rod (lbs.)	Aggregates >0.84 mm (%)	Mechanical stability (%)
Check	0.0	66.9	71.8
Concentrated Borascu	18.0	61.0	71.1
Polybor Chlorate	10.0	51.7**	63.1
Sodium Chlorate	6.0	53.5*	69.0
CMU	0.25	53.7*	61.5
CMU	0.5	53.0*	66.8
LSD .01		14.1	
LSD .05		9.8	NS

* Significantly less than the check at the 5 percent level.
** Significantly less than the check at the 1 percent level.

The estimated erodibility of the soil treated with various sterilants under dryland and irrigation is shown in Table 3. All of the treated plots were more susceptible to erosion than the checks primarily because of weed residues on the untreated areas. No sorghum residues were produced because of drought. Concentrated Borascu treated soil had the lowest estimated erodibility in both the irrigated and dryland experiments. Under irrigation, Polybor Chlorate treated soil had the highest estimated erodibility. Under dryland conditions, CMU treated soil appeared to be most erodible.

Table 3. Estimated erodibility of dryland and irrigated soil treated with soil sterilants.

Soil sterilant	Rate per sq. rd. (lbs.)	Erodibility in tons/acre Dryland	Irrigated
Check*	0	0.4	0.03
Concentrated Borascu	18	1.7	3.8
Polybor Chlorate	10	4.0	10.0
Sodium Chlorate	6	3.8	6.5
CMU	¼	9.6	6.6
CMU	½	—	7.2

* Residues from weeds were produced only on the check plots; 743 pounds per acre under dryland and 2,229 pounds per acre on the irrigated.

Summary and Conclusions

Pullman silty clay loam previously treated with soil sterilants was dry sieved to determine the percent soil aggregates larger than 0.84 mm and mechanical stability of these aggregates. Under dryland conditions, Concentrated Borascu, Polybor Chlorate and sodium chlorate increased the percentage of soil aggregates over 0.84 mm in size and mechanical stability as compared to the check. Soil aggregation was decreased when sterilants were disked into the soil immediately after application. When soil sterilant treatments were followed by irrigation, Concentrated Borascu was the only sterilant that did not reduce aggregation. The estimated erodibility of all treated plots was greater than those receiving no treatment. Concentrated Borascu treated soils had lower estimated erodibility than soils treated with other sterilants.

This preliminary study indicates the erodibilty of soils treated with sterilants in the second winter after application. The over-all erosiveness of a soil treated with a soil sterilant will depend on the amount of aggregation during succeeding years and the speed with which plant growing conditions are established in the soil. Since an erosion hazard existed on fine textured soil of low wind erosion susceptibility in this study after soil sterilant application sterilization of large areas of coarser textured soil might be hazardous and could lead to very serious wind erosion.

Literature Cited

1. Chepil, W. D. Improved rotary sieve for measuring state and stability of dry structure. Soil Sci. Soc. Amer. Proc. 16: (2)113-117. 1952.
2. Chepil, W. D., Woodruff, N. P., and Zingg, A. W. Field study of wind erosion in Western Texas SCS-TP-125. February 1955.
3. Coover, James R., Van Doren, C. E., and Whitfield, C. J. Some Characteristics of Pullman Soils on the Amarillo Experiment Station. Texas Agric. Expt. Sta. Misc. Publ. 97. 1953.

[1] These experiments were conducted cooperatively by the Texas Agricultural Experiment Station and the Soil and Water Conservation Research Branch, Agricultural Research, U.S.D.A. Approved by T.A.E.S. T.A. 2282.
[2] Assistant Agronomist at Bushland, Texas, and Associate Professor at College Station, Texas, respectively.

PRE-EMERGENCE HERBICIDE TREATMENTS ON LIMA BEANS, SNAP BEANS AND SWEET CORN

C. C. Singletary and J. W. Herron[1]

Results of preliminary tests in 1954 indicated that DNBP salt and CIPC, when applied as pre-emergence treatments on large seeded vegetables such as sweet corn, snap beans, and lima beans, may eliminate hand weeding and cultivation for control of weeds. On ob-

XUM

servation plots in 1954, hand weeding and cultivation for weeds was not required on plots treated with either of the above materials.

Herbicides treatments in the 1955 tests included SES and Natrin 80S each at the rates of 4, 6 lb/A in addition to DNBP 4 lb/A and CIPC 6, 8 lb/A. The materials were applied in 50 gal/A of water on June 6, immediately following planting of Golden Cross sweet corn, Topcrop snap beans, and Fordhook 242 lima beans. Each treatment was replicated five times. In each plot the rows were 15 feet long and spaced three feet apart. Applications were made with a knapsack sprayer to the entire area. The plots were not cultivated or weeded during the growing season and no herbicide treatments were made following the initial application.

Weed counts were taken on July 20. Two counts were made in each plot, with one square foot for each count.

The weed control for each chemical treatment was more than 75 per cent as compared to the check. Weed growth was not as vigorous in chemically treated plots as in untreated plots. It was noted that SES and Natrin did not control *Portulaca oleracea*.

From observations made on July 21, there was no apparent injury to any crop plants from treatments with DNBP and CIPC. There was some degree of injury to all crop plants from treatments with SES and Natrin.

Harvest records were taken on August 15 for snap beans and September 9 for sweet corn. The lima beans failed to set pods during the hot summer months and consequently no yields were recorded. Higher yields of snap beans and sweet corn were obtained from plots treated with DNBP and CIPC than from plots treated with SES, Natrin, or the untreated areas. The yield of snap beans and sweet corn varied considerably among plots of each treatment. This variability in yield could not be explained completely on the basis of weed growth. The calculated yield per acre of snap beans for the plots treated with DNBP and CIPC was over 150 bu/A as compared to less than 50 bu/A for the untreated plots. The trend for yield of sweet corn was similar to that of snap beans.

[1] University of Kentucky, Lexington, Kentucky.

GROWTH OF CUCUMBERS, CORN, FIELD AND SNAP BEANS FOLLOWING CHEMICAL SPRAYS FOR CONTROL OF QUACKGRASS[1]

B. H. Grigsby, S. K. Ries and B. R. Churchill[2] and R. H. Hamilton[3]

Control of quackgrass by fall or spring applications of TCA can be obtained in most Michigan soils. Certain crops, however, may be severely damaged when planted in soils which have received an application of 20 pounds per acre, or more, of TCA. All types of beans are very sensitive to such treatment, corn also has been reported to be subject to TCA injury.

Results obtained with some of the more recently developed herbicides have suggested that control of quackgrass and satisfactory crop production may be possible within a single growing season.

In order to test the feasibility of this type of quackgrass control, a two-year old sod of quackgrass, on a light sandy soil, was treated with dalapon, amino triazole, maleic hydrazide, alone and in various combinations. Seven days after spray application the land was plowed, 400 lbs. per acre of fertilizer drilled in, and the soil was prepared for planting.

The following herbicidal applications were made in three replication:

1. No chemical treatment.
2. Dalapon, 10 lbs. per acre.
3. Amino triazole, 2 lbs. per acre.
4. Maleic hydrazide, 2 lbs. per acre.
5. Dalapon, 5 lbs. plus amino triazole, 2 lbs.
6. Dalapon, 5 lbs. plus Maleic hydrazide, 2 lbs.
7. Amino triazole, 2 lbs. plus Maleic hydrazide, 2 lbs.
8. Dalapon, 5 lbs., amino triazole, 2 lbs. plus Maleic hydrazide, 2 lbs.

A randomized split block experimental design was used, thus it was possible to plant blocks of snap beans, field beans, corn and cucumbers and have all treatments fall within the crop blocks.

Emergence of all crops was normal and satisfactory crop stands, as well as a number of broad leaved weeds were obtained. Quackgrass control ratings, based on visual observations, were made three weeks after and are shown in Table 1. All crops were given two shallow cultivations. and the snap beans and cucumbers were hand hoed to remove broad leaved weeds. All crops were harvested in the normal way for each and the yields are shown in Table 1. The yields for snap beans, corn and field beans are low, due to unseasonably high temperature and dry soil at flowering time.

The quackgrass ratings show that 10 lbs. dalapon gave a highly satisfactory control of quackgrass. They also show that half this amount of dalapon, in combination with two lbs. of either amino triazole or maleic hydrazide gave control to an extent approximately equal to that produced by 10 lbs. of dalapon.

Table 1. Chemicals, control ratings and mean yields of four crops on spring treated quackgrass sod.

Chemical	Control* Rating	Mean yields, bushels per acre Cucumber	Corn	Field B.	Snap B.
None	1.0	47.5	1.6	5.6	12.0
10 lbs. Dalapon	7.4	55.5	7.8	4.1	29.3
4 lbs. Amino triazole	3.4	48.4	5.2	7.2	20.1
4 lbs. Maleic hydrazide	2.6	41.7	4.2	4.1	17.3
5 lbs. Dalapon 2 lbs. Amino triazole	7.4	43.3	6.2	5.3	20.1
5 lbs. Dalapon 2 lbs. Maleic hydrazide	7.2	55.8	7.8	7.6	29.7
2 lbs. Amino triazole 2 lbs. Maleic hydrazide	2.8	53.7	3.6	6.8	16.8
2 lbs. Amino triazole 2 lbs. Maleic hydrazide 5 lbs. Dalapon	6.6	47.2	13.0	8.0	23.1
L. S. D. 5% 1%	1.0 1.3	NS	NS	NS	NS

Rating scale 1=no control.
6=commercially acceptable control.
9=complete kill.

Under the conditions of this experiment neither maleic hydrazide nor amino triazole, alone, or in combination with each other, gave statisfactory control of quackgrass.

Examination of the plots in October revealed that quackgrass was present in all plots but the amount of growth was directly proportional to the control ratings made in July.

The yield data for snap beans show that all treatments permitted growth of a crop superior to that of untreated plots. The data also show that wherever appreciable control of quackgrass was obtained, a trend toward increase in the crop yield followed. In some other experiments dalapon has caused injury to beans but this effect was not observed in this trial.

XUM

Results from the cucumber harvest do not show any injurious effects from dalapon. Yields slightly lower than those from untreated plots were obtained where maleic hydrazide and amino triazole were applied. These differences were not satistically significant.

The corn yields were so poor, due to the dry season, that no conclusions can be drawn. It should be noted, however, that a markedly greater yield was obtained in all plots where effective control of quackgrass was secured. Early competition between corn and grass appeared to be an important factor in this trial.

The field bean data indicated that 10 pounds of dalapon depressed the bean yield even though grass control was obtained. However, a rate of 5 pounds of dalapon, in combination with maleic hydrazide, gave a yield somewhat greater than that from untreated plots.

SUMMARY

1. Four pounds of amino triazole, four pounds of maleic hydrazide and a combination of two pounds each of these herbicide failed to give effective control of quackgrass.
2. Ten pounds of dalapon alone, and five pounds in combination with two pounds each of amino triazole and maleic hydrazide, controlled quackgrass.
3. Yields of corn and snap beans were not reduced by applications of any of the herbicide treatments.
4. Field bean yields were reduced slightly in plots treated with dalapon and amino triazole.
5. Cucumber yields showed a trend toward reduction in plots where maleic hydrazide alone and in combinations with dalapon were used.
6. Competition from quackgrass had more effect on crop yield than did any herbicidal treatment.

[1] Journal article **1857.** Mich. Agric. Exp. Station.
[2] Departments of Botany and Plant Pathology, Horticulture and Farm Crop, respectively.
[3] Agent Field Crops Research Branch, A.R.S. U.S.D.A., Michigan State University, East Lansing, Michigan.

SOME NEW POSSIBILITIES FOR WEED CONTROL IN CARROTS

G. F. Warren[1]

Stoddard solvent is an excellent selective post-emergence herbicide for carrots and its use has been a standard commercial practice for several years. However, the cost of material is high and the lack of any residual effect often makes necessary two or even three applications in a season. An economical weed killer with residual properties would be desirable.

In greenhouse screening tests conducted during the past four years, carrots were found to be tolerant to both pre- and post-emergence applications of several herbicides at rates which controlled many important weeds. Especially outstanding was their resistance to sprays of CIPC in either water or Stoddard solvent. Its use in the latter carrier was found to give residual control of several species in addition to excellent contact kill of all emerged weeds on which it was tried with the exception of ragweed. Another herbicide that looked especially promising was 2-chloro-4, 6-bis (diethylamino)-s-triazine.

In 1955 a field experiment was conducted on muck soil to obtain additional data on the performance of these materials. Red Cored Chantenay carrots sown April 21 were sprayed late in the afternoon on May 4 using a power sprayer and 26 pounds pressure. The carrots were in the cotyledon stage and many weeds were present when the treatments were applied. The temperature was approximately 80°F., the soil was dry, and there was no rainfall for three days after spraying and only .37 inches during the following two weeks. The treatments were replicated four times.

The treatments used and rates per acre were as follows: Stoddard solvent at 50 and 100 gallons undiluted, CIPC at 4 and 8 pounds in both 25 and 50 gallons of Stoddard solvent per acre, CIPC at 8 pounds in 50 gallons of water, 2-chloro-4, 6-bis (diethylamino)-s-triazine at 12 pounds in 50 gallons of water.

Weed counts made May 20 showed good to excellent control of the following weed species with all treatments: purslane (*Portulaca oleracea*), smartweed (*Polygonum spp.*), pigweed (*Amaranthus retroflexus*) and annual grasses. However, 50 gallons of Stoddard solvent alone and 8 pounds of CIPC in water did not give quite as good control as the other treatments. All plots were kept hand weeded throughout the remainder of the season. It was noted, however, that on June 7 all treatments except 50 and 100 gallons of Stoddard solvent alone were giving good residual control of purslane which was then the principal weed present.

Carrots were injured and yields significantly reduced by CIPC at 4 pounds in 25 gallons of Stoddard solvent and at 8 pounds in both 25 and 50 gallons of Stoddard solvent. Decreasing the spray volume of these mixtures from 50 to 25 gallons definitely increased the damage to the carrots. The other treatments had little or no noticeable effect on the crop and did not significantly influence the yield.

Twelve pounds per acre of 2-choloro-4, 6-bis (diethylamino)-s-triazine and the mixture of 4 pounds of CIPC in 50 gallons of Stoddard solvent both appear worthy of further trial as selective herbicidal treatments for carrots. Due to the lower rates of CIPC necessary to give residual weed control on mineral soils the amount could undoubtedly be reduced which would give a greater margin of safety for the crop. It is also suggested that carrots might be more resistant to this treatment at a slightly later stage of growth.

[1] Purdue University, Agricultural Experiment Station, Lafayette, Indiana.

PRE-EMERGENCE WEED CONTROL IN POTATOES IN MEXICO'S HIGH MOUNTAIN VALLEYS

Lowell S. Gleason, Jorge Nieto, and Julian Ramirez[1]

The summer production of potatoes in Mexico is located principally in the high mountain valleys and on the high plateau near Mexico City. This study was conducted on the Campo Experimental Santa Elena which is located in a mountain valley at an elevation of 8200 ft. above sea level. The temperature is typically cool in both the wet and dry seasons. The wet season extends from June to September during which time approximately 40 inches of rain falls. This abundant rainfall, coupled with the cool temepratures and cloudy skies make it difficult or impossible to work machinery in the field during much of the wet season. It is during the wet season that potatoes are grown.

The main factors which favor the use of a chemical to control weeds in this region are the high rainfall and a wild cucurbit (*Cicyos angulatus*) locally called calabacilla. This weed is a problem because it is a climbing type of plant and if allowed to establish itself will overtop the tallest or the most densely growing plant. The seeds of calabacilla start to germinate with the first rains and continue to germinate until mid-July when the crops are too large to cultivate which allows it to become established.

XUM

Table 1.

Mean Yield of Potatoes in Bu./A. in Toluca, Mexico, 1954.

Treatment	* Rate of Application 1	2	3	4	Mean
DNBP salt	189	233	253	232	144
2,4-D ester	181	147	195	182	227
2,4-D amine	190	184	128	139	177
Endothal	116	138	197	167	160
CIPC	169	218	163	140	155
CMU	161	190	143	82	173
Weedy check	65	102	61	90	79
Mean	153	173	163	148	

	* Rates of Application in Lbs./A. 1	2	3	4
DNBP	4.0	8.0	12.0	16.0
2,4-D ester	1.0	2.0	4.0	8.0
2,4-D amine	1.0	2.0	4.0	8.0
Endothal	1.0	2.0	4.0	8.0
CIPC	2.0	4.0	8.0	12.0
CMU	0.1	2.0	3.0	4.0

	5%	1%
LSD between chemical means	40.7	55.8
LSD between rates means	25.0	32.9
LSD between rate means within one chemical	66.7	87.7
LSD between chemical means within a rate	52.8	72.4

Table 2.

Green weight of weeds in potato plots in Tons/A. in Santa Elena, Mexico, 1954.

Treatment	* Rate of Application 1	2	3	4	Mean
DNBP salt	3.5	1.9	0.9	0.5	1.7
2,4-D ester	9.0	3.3	2.5	1.1	3.9
2,4-D amine	5.9	3.1	3.2	1.7	3.2
Endothal	18.1	14.5	15.0	16.8	16.1
CIPC	9.8	5.8	5.4	3.9	6.2
CMU	13.6	7.2	3.1	0.6	6.1
Weed check	31.1	28.1	23.7	23.5	26.4
Mean	13.0	9.1	7.5	6.8	

* Rates of application are the same as in Table 1.

	5%	1%
LSD between chemicals	3.7	5.0
LSD between rates	1.3	1.5
LSD between rates within one chemical	3.9	4.7
LSD between chemicals within one rate	3.7	5.1

The mean yield of potatoes in 1954 are shown in Table 1. The green weight of weeds from the same plots are shown in Table 2. On these plots chemicals were applied pre-emergence over the whole plot and no cultivation was used. The yields in general are low because they were not cultivated but the relative yields are believed to be of value.

The best potato yields and weed control were obtained from the DNBP alkanolamine salt plots at the higher rates of application. However, from an economic point of view, the 8 lbs. rate is better because it gave a sufficent degree of weed control and a yield that was not significantly different from the higher rate, but less expensive. The 2,4-D ester and amine gave similar results at the lower rates and were not significantly different from the DNBP. At the higher 2,4-D rates there was evidence of damage to the plants and yield reductions, especially with the amine. The CMU treatments resulted in low yields which can be attributed to weed competition at the lower rates and chemical injury at the higher rates. Endothal and CIPC plots gave low yields due to weed competition. However, no calabacilla grew in the endothal or CIPC plots so these chemicals were tested in 1955. The green weight of weeds in the weedy check plots show the extent of the weed problem encountered in this region.

Table 3.

Mean yields of potatoes in Bu./A. in Santa Elena, Mexico, in 1955.

Treatment	* Rate of Application 1	2	3	4	Mean
2,4-D ester	254	215	197	222	222
DNBP NH_3 salt	274	252	244	246	253
2,4-D and Endothal	314	290	334	266	301
2,4-D and CIPC	259	162	137	129	181
Mean	274	231	237	216	

	* Rates of Application in Lbs./A. 1	2	3	4
2,4-D ester	0	0.5	1.0	1.5
DNBP	0	2.0	4.0	6.0
2,4-D	0	0.5	0.5	0.5
Endothal	0	0.5	1.0	2.0
2,4-D	0	0.5	0.5	0.5
CIPC	0	2.0	4.0	6.0

	5%	1%
LSD between chemical means	92	133
LSD between rate means	39	54
LSD between rate means within a chemical	80	108
LSD between chemical means within a rate	112	154

Table 3 shows the yield of potatoes from the 1955 test. These plots were treated pre-emergence but in contrast to the 1954 tests were treated in a 30 cm. band over the row, cultivated once by tractor and hilled once with a lister type plow. The 2,4-D and CIPC mixtures were used in the hope that the CIPC would control the calabacilla and the 2,4-D would control the other weeds. However, there was evident plant damage and yield reduction which can be ascribed to CIPC. The endothal and 2,4-D mixtures were selected on the basis of the 1954 data. These treatments were consistently better than the cultivated check but this can be attributed to poor randomization rather than an effect of the chemical. The 2,4-D and DNBP treatments were not significantly different from the check as would be expected from the 1954 data. All treatments gave sufficient weed control.

Table 4.

The relative cost per acre, in dollars, between a conventional system of cultivating potatoes and a system using DNBP.

Conventional system		System using DNBP NH_3 salt	
Two cultivations by tractor	$1.33	1 quart of DNBP	$ .72
Three cultivations by hand	4.05	Application cost	.10
		One cultivation by tractor	.65
	$5.38		$1.47

The cost of a chemical treatment is always an important factor in a country, such as Mexico, which has cheap labor. Table 4 shows the relative cost in dollars between the conventional system of cultivating potatoes and a system employing a chemical. Besides the financial advantage for the chemical there is an added convenience in a high rainfall area such as Sta. Elena, in that there is less risk of poorly timed cultivations, getting machinery stuck in the field and many other problems encountered in a wet field. Also, the ranchers like to avoid the use of large groups of labor such as are necessary for hand weeding.

In summary, the use of a chemical to control weeds in potatoes appears to be economical and practical in a country of cheap labor when banded treatments can be used to lower the cost of chemical and heavy rainfall causes an acute weed problem.

[1] Rockefeller Foundation, Mexico City, Mexico.

XUM

WEED CONTROL AROUND NEWLY TRANSPLANTED APPLE TREES[1]

D. D. Hemphill[2]

In the early spring of 1955 an apple orchard, consisting of approximately 600 trees of Delicious, Golden Delicous and Jonathan varieties was established on a portion of the Horticultural Farm. The farm is situated on the Missouri River hills with steep grades and a loess (wind-lain) type of soil which erodes very badly.

This area was terraced the preceeding winter and seeded soon after planting the trees to a permanent sod of bluegrass and ladino clover with oats as a nurse crop.

Weed control on such sites usually consists of cultivating a strip along the tree row, hand hoeing around each tree, or mulching an area around each tree. Due to the possibility of mouse injury when trees are mulched and due to the extreme tendency of this soil to erode it was decided that weed control around the base of each tree would have to be accomplished by hand cultivation.

The objective of this experiment was to determine the feasibility of controlling weeds around young apple trees by chemicals instead of by hand cultivation.

Treatments planned for this planting were as follows: CIPC—14 lb./acre, CPCPC (1-chloropropyl-2) N-(3 chlorophenyl) carbamate—14 lb./acre, CMU—2 lb./acre, Dalapon—2 lb./acre, CMU—2 lb.+Dalapon 2 lb./acre, Erbon (2-(2,4,5-trichlorophenoxyethyl 2,2-dichloropropionate) 10 lb./acre, dinitro fortified oil emulsion (20 gal. oil+2 qt. DNBP in 100 gal.) 80 gal./acre and Control—hand cultivated.

Treatments were made in early May and an area 6′ x 6′ was sprayed around each treated tree and a like area was spaded around each Control tree. At time of treatment the oat nurse crop had germinated and was 2 to 3 inches in height. In case some of the sprays were too caustic the trunk of the tree was protected from the spray by placing a metal cylinder around it while spraying. Due to late arrival of the chemical the Erbon treatments were not made.

Weed counts and observations on injury were made approximately eight weeks after treatment. Degree of weed control and tree injury are indicated in the following data:

Treatment	Injury	Per cent Weed Control* B. L.	N. L.
Control	—	—	—
CIPC—14 lb.	None	47	98
CPCPC—14 lb.	None	85	89
CMU—2 lb.	Severe-erratic	86	96
Dalapon—2 lb.	None	67	85
CMU—2 lb. + Dalapon—2 lb.	Severe-erratic	93	99
Oil + DNBP—80 gal.	None	35	22

* Weed counts made eight weeks after treatment.

CIPC gave excellent control of most weeds except trumpet creeper (*Campsis radicans*) and ragweeds (*Ambrosia spp.*). CPCPC gave better control of broad-leaved weeds, especially ragweeds, than CIPC. Neither chemical caused detectable injury.

CMU gave excellent control of all weeds except trumpet creeper, however, injury ranged from none to severe chlorosis and stunting or killing of trees. Dalapon gave adequate control of grasses, but failed to give satisfactory control of broad-leaved weeds. No injury was evident in Dalapon treated trees.

Combination of CMU and Dalapon controlled most weeds except trumpet creeper, but the same erratic injury resulted as with CMU alone.

Dinitro fortified oil emulsion gave satisfactory control of most weeds for a period of 4 to 5 weeks. This treatment is not entirely satisfactory because two or three applications at approximately four week intervals are necessary for weed control throughout the season.

Twig growth measurements indicated no reduction in growth by chemical treatments except in the case of CMU and CMU plus Dalapon. Many trees treated with CMU showed no evidence of injury and made as much growth as hand cultivated controls while approximately 50 per cent of the trees exhibited severe chlorosis and stunting or were killed. Extreme variation in response of trees to CMU treatment was not due to a difference in varietal susceptibility.

The most promising treatment considering all factors, was CPCPC. Excellent control of most weeds for the entire season was obtained without any detectable injury. None of the treatments were effective against trumpet creeper.

Treatments will be continued in following seasons.

[1] Journal Series Paper No. 1592. Missouri Agricultural Experiment Station.
[2] University of Missouri, Columbia, Missouri.

WEED CONTROL IN STRAWBERRIES

J. W. Herron and C. E. Chaplin[1]

The results of 1954 tests showed that SES and Natrin 80S were at that time the most promising herbicides for weed control in strawberries. Both materials applied at low rates gave satisfactory weed control without causing significant inhibition of runner formation, rooting or reduction in yield. Therefore, these two chemicals were used in the 1955 tests.

Methods and Materials

The variety used was Tennessee Beauty. Each material was applied at the rate of 3, 4, 6 lb./A in 100 gallons of water. Each treatment was replicated five times and consisted of an area 10 feet by 2 feet centered over rows spaced 4 feet apart. The initial treatments were made May 6, two weeks after setting of the plants. One series of plots was treated with SES and Natrin on May 6, June 8, July 27, and September 19. Another series was treated on May 6, June 8, and September 19. All materials were applied with a knapsack sprayer. All plots were cultivated and hand weeded prior to each application.

Weed counts were taken on June 6 and July 19. Two counts were taken from each plot and consisted of two areas each containing one square foot. Runner counts were taken on all plants on July 19. Runner and rooting counts were made on all plants on September 9.

Results and Observations

Applications made on May 6 did not control weeds as well as the later applications, but the control from all treatments, except SES 3 lb./A, was significant. This was probably due to an excessive amount of rainfall (3 inches) during a period of two weeks following the May 6 treatments. Weed control from treatments applied on June 8 was highly significant on all plots at the one per cent level, with the percentages of weed control ranging from 82 per cent to 95 per cent.

From counts made on July 19, there was some indication of runner inhibition of plants treated with SES 6 lb./A, but the plants apparently recovered by September 9, since total counts made at that time revealed no significant decrease in runner formation as a result of any of the treatments. In fact, runner development appeared to be stimulated as a result of most treatments, although due to the wide variations in replications, the stimulation was not significant. Runner formation on plots treated with Natrin 6 lb.%A was slightly less than the checks, but not significantly so. Rooting counts made September 9 showed that rooting of the runners was not significantly affected from treatments with

either SES or Natrin at any of the concentrations used. However, it was noticed that there was considerable burning of the root initials as they appeared on new runner plants. They apparently recovered enough to root by September 9, but the effect on production will not be known until next year.

[1] University of Kentucky, Lexington, Kentucky.

WEED CONTROL IN WISCONSIN CRANBERRY MARSHES

Malcolm N. Dana[1]

Cranberry production is a highly specialized agricultural enterprise. Weed control is one of the most serious cultural problems faced by the cranberry grower.

In a 1953 survey a wide range of weed species were found to be present in Wisconsin cranberry marshes. The chief weed pests were classified in the following families: *Cyperaceae* (sedges), *Juncaceae* (rushes), *Gramineae* (grasses), *Compositae* (ragweed, Joe Pye weed, beggar ticks), *Polygonaceae* (smartweeds), *Rosaceae* (*Potentilla* sp., *Rubus* sp.), *Hypericaceae* (St. Johnswort), *Salicaceae* (willow, aspen), *Equisetaceae* (horsetail), and *Polypodiaceae* (marsh fern, sensitive fern.)

Weed control measures commonly practiced in Wisconsin cranberry marshes may be separated into two groups, mechanical and chemical. Mechanical control takes on several forms. Hand pulling of weeds, once a standard practice, is now used only to a very limited extent because of labor costs. Young, non-bearing beds are sometimes hand-weeded and occasionally small, localized areas of ferns or smartweeds may be hand-pulled from bearing beds. A few growers who have a problem with wiregrass, *Carex oligosperma*, go over their beds with a roller. The machine breaks over the wiregrass stems and delays their seasonal development. Any effects are temporary and for this reason the method does not seem to offer much promise of widespread acceptance. The most widely-used mechanical control of weeds in Wisconsin marshes is the use of special rotary clippers for topping the weeds above the cranberry vines. The weeds are clipped two or three times per summer, a practice that reduces the amount of shading by the weeds as well as reducing seed production by the weeds.

Chemical weed control in Wisconsin cranberry marshes depends upon the use of petroleum derivatives (Stoddard solvent, kerosene, mineral spirits.) These materials applied in the spring before cranberry growth starts are effective in reducing the population of a wide range of grassy weeds. Suggested rates range from 300 to 500 gallons of oil per acre or enough to thoroughly wet the crowns of the weeds. Among the weeds that may be reduced by oil treatments are: Wiregrass (*Carex oligosperma*), wide leaf grass (*Carex rostrata*), Satin grass (*Muhlenbergia sylvatica*), rattle snake grass (*Glyceria Canadensis*), squirrel tail grass (*Hordeum jubatum*), sickle grass (*Leersia oryzoides*) and other minor species. Dormant cranberry vines are remarkably tolerant of the petroleum products. However, once the vines start growth the oil sprays can no longer be used safely on bearing vines because of potential damage to the fruit crop and new growth. Weeds which start growth later than the cranberries cannot be treated by a general contact killer such as Stoddard solvent because of the potential injury to the vines. For a more detailed treatment of oil sprays for cranberry weed control in Wisconsin the reader is referred to Roberts (1).

Iron sulfate is sometimes used to hold certain weeds in check. Anemone (*Anemone canadensis*), ragweed (*Ambrosia artemisiifolia*), beggar ticks (*Bidens sp.*), sensitive fern (*Onoclea sensibilis*), and others may be defoliated and temporarily checked by wetting the plants with a saturated iron sulfate solution during the growing season. Cranberry vines will not be seriously injured by this treatment.

Copper sulfate is occasionally used to control star grass (*Dulichium arundinaceum*). Best results are obtained by dusting the material on the weed when the plants are wet with dew or rain.

For the control of ditch weeds, sodium arsenite and Stoddard solvent find limited use.

The amine form of 2,4-D is used extensively for hand-stripping of swamp smartweed and willows. The material is mixed at the rate of one quart of 2,4-D amine per gallon of water. This solution is then wiped on individual weeds by laborers wearing cloth gloves dipped in the solution.

Growers in other cranberry areas sometimes use common salt, sodium nitrate, paradichlorbenzene, and sodium arsenate as reported by Cross (2). None of these materials are used in Wisconsin.

Preliminary reports on the use of selective herbicides have been made by several investigators. Dana (3) reported the successful use of dalapon to control wideleaf grass (*Carex rostrata*) in Wisconsin. Aldrich (4) reported that amino triazole was successfully used to control red root (*Lachnanthis tinctoria*) in New Jersey bogs. The work this summer in Wisconsin indicated that cranberries were tolerant of two pounds per acre of amino triazole when the material was applied in the cranberry white bud stage. Expanded work with this material may show it to be effective on a number of the worst weed pests. A preliminary report in Cranberries (5) stated that IPC had been used successfully by several growers in Oregon to control certain grasses in that area. Experimental tests by growers in Wisconsin have shown that TCA at 40 to 80 pounds per acre would control sickle grass (*Leersia oryzoides*) although damage to the vine was too great to permit recommendation of this material.

The weed control program in Wisconsin cranberry marshes is built around good cultural practices and the use of non-selective hericides. Preliminary reports from several sources suggest that further investigation of selective herbicides may prove them of value in the program.

Literature Cited

1. Roberts, R. H. Cranberry Weed Killing. Cranberries 14 (No. 8): 6, 8. 1949.
2. Cross, C. E. Chemical Weed Control in Massachusetts Cranberry Bogs. N. E. Weed Control Conf. Proc.: 126-131. 1948.
3. Dana, M. N. The Use of Dalapon to Kill Wideleaf Grass in Cranberries. N. C. Weed Cont. Conf. Res. Rept. 1955. *In press.*
4. Aldrich, R. J. Control of Red Root (*Lachnanthis tinctoria*) in Cranberries. N. E. Weed Control Conf. Newsletter No. 2:20. 1955.
5. Cranberries. Oregon News-Cranberries. 19(No. 3):7, 1954.

[1] University of Wisconsin, Madison, Wisconsin.

CHEMICAL GROWTH SUPPRESSION OF NURSERY COMPANION CROPS

L. C. Chadwick and W. D. Chambers[1]

To suppress the growth of nursery companion crops, herbicides used at the rates shown below were applied as directed sprays in a field nursery of 7-year *Taxus cuspidata intermedia*. The companion crops included 1000 sq. ft. plots of Kentucky blue grass, chewings fescue, birdsfoot trefoil, or alsike clover. These were cut to approximately 3" in late June and the clover was recut to a similar height on July 10. The herbicides were applied to replicated plots on July 11.

Results: By visual observation it was considered the rate of growth of the companion crops was much less in the treated plots for 3 to 4 weeks after the applications. Evaluation of the amount of growth was made 5 weeks after treatment by taking 40 measurements per plot. These, as shown in the table below, indicated that some growth suppression was obtained, especially where the higher rate of MH was applied.

Inches of growth 5 weeks after treatment

Treatment	Rate lb./A	Kentucky blue grass	Chewings fescue	Birdsfoot trefoil	Alsike clover
MH,15 plus 2,4-D	½	2.65	2.75	.....	3.70
MH,7.5 plus 2,4-D	½	3.75	3.55	2.95	5.30
Check		4.85	6.35	4.95	4.60

In another series of tests, 1000 sq. ft. replicated plots in the same Taxus nursery were treated with CIPC, 2,4-D, these two in combination, and MH plus 2,4-D at respective rates of 7.5, 1, 7.5 and 1, and 10 and 1 lb./A. Applications were made on May 12 and August 4 for all the treatments and again on September 1 for all treatments but 2,4-D and MH plus 2,4-D. For the August 4 and September 1 applications, the 2,4-D rate was reduced to ½ lb./A. The plots contained volunteer vegetation consisting mainly of green foxtail, German millet, crabgrass, quack grass, pigweed, Canada thistle, field bindweed, dandelion, lambs quarter, and alsike clover. Between the first and second applications, the plots were tractor cultivated. Visual observations of growth suppression were made 5 weeks after the May 12 application and 7 weeks after the August 4 application.

Results: CIPC was effective only on grasses, causing growth stoppage and foilage browning. 2,4-D provided good control of broadleaf weeds following the May 12 treatment but only partial control thereafter. The MH and the 2,4-D combination gave control comparable to that of 2,4-D alone. Although not too effective following the August 4 application, CIPC plus 2,4-D caused the most suppression of growth of both the grasses and the broadleaf weeds.

[1] Ohio Agricultural Experiment Station, Ohio State University, Wooster, Ohio.

MIXTURES OF HERBICIDES FOR NURSERY WEED CONTROL

LeRoy G. Holm and Ray Taylorson[1]

Herbicides presently available for use on small plants in forest and ornamental nurseries have slowly begun to change our management practices. Our need for chemical weed control is most pressing in these smaller plantings which are so expensive to weed and so easily disturbed or uprooted during the weeding process. It has been said that crops which are hand-weeded are weedy more of the time than they are clean and thus they must be weeded again and again. With chemicals such as are now available for use in nurseries it is sometimes possible to keep the crop clean *all of the time* and thus allow the plant to make the best possible development without competition from weeds.

The work reported here is concerned with the continuing search for materials which will provide control for a longer period of time and will be effective against more kinds of weeds. This has been accomplished in our experiments by using CMU or NP in mixtures with SES.

Two year old seedlings of Blue spruce, Black Hills spruce, Norway spruce, Scotch pine, Red Cedar, Austrian pine, White pine, Arbor vitae, and Douglas fir were transplanted to research plots on a sandy loam in the fall and the application of herbicides began the following spring. All chemicals were applied at 40 gallons of water per acre as an over-all spray to 4' x 20' areas. The herbicides used were: SES (2,4-dichlorophenoxyethyl sulfate); Sesin (2,4-dichlorophenoxyethyl benzoate); Natrin (2,4,5-trichlorophenoxyethyl sulfate); Methin (2 methyl, 4 chlorophenoxyethyl sulfate); CMU (3-(chlorophenyl), 1-1, (dimethyl urea); NP (Naphthylphthalamic acid). The predominant weed species of the area were lamb's quarters, shepherd's purse, peppergrass, bindweed, pigweed, and several annual grasses.

Mixtures of SES with CMU or NP provided 90 to 100% control for the first 10 weeks (See Table I). The remaining treatments gave satisfactory weed control but were less effective. With the exception of the CMU plus SES mixture, each plot was clean-weeded and retreated in mid-July. In Mid-November weed control with NP plus SES was 70% and that with Natrin was 60%. Sesin, SES, and Methin conrolled less than 50% of the weeds at this date.

Table I. Weed Control in Conifers*

Chemical (lbs./A)	Percent of Weeds Controlled	
	Broadleaves	Grasses
CMU ½ plus SES 4	98.7	93.6
NP 2½ plus SES 2½	87.5	87.5
SES 4	80.8	67.8
Sesin 4	86.6	75.0
Natrin 4	71.1	60.4
Methin 4	85.1	71.7

* Treated 4/21/54. Weed counts 7/13/54.

In the spring of the following season SES and mixtures of SES with CU or NP were again applied to these plots in April. The data on weed control 6 weeks later may be seen in Table II. The excellent weed control shown by the mixtures in this second season is not simply the result of a stronger chemical action but reflects also the desirability of having good weed control all through the preceding season. Fewer weed seeds were produced and returned to these areas than where SES was used alone. A larger number of seedlings of perennial weeds had also been able to gain a foothold in the SES plots.

Table II. Weed Control in Conifers*

Chemical (lbs./A.)	Percent of Weeds Controlled
CMU ½ plus SES 4	88.8
NP 2 plus SES 2	76.6
CMU ¼ plus SES 4	74.7
SES 4	46.5

* Treated 4/28/55. Weed counts 6/2/55.

Terminal growth measurements were taken in several species in mid-July of the second season in an effort to detect injury resulting from the use of the herbicides. The data on a spruce, a fir, and a pine may be seen in Table III. There was no apparent injury from any treatment with the exception that Black Hills spruce and Douglas fir were retarded slightly where NP was used three times in the two seasons. Visual observations on many other species, however, revealed no detectable stunting from this herbicide.

XUM

Table III. Terminal Growth of Conifers Treated with Herbicides*

Chemical lbs./A.	No. of Treatments in 2 Seasons	Growth in Inches B.H. Spruce	Austrian Pine	Douglas Fir
Control		4.6	5.1	3.1
CMU ½ plus SES 4	2 X	5.4	8.6	3.6
SES 4	3 X	5.0	7.7	3.2
NP 2 plus SES 2	3 X	3.9	7.7	2.3

* Measured 7/14/55.

In April of 1955 these chemicals were again applied to new research plots in which the following additional species had been planted: White spruce, Norway pine, Concolor fir, Austrian pine, and Mugho pine. Terminal growth measurements in mid-July revealed no injury as a result of the chemical treatment.

Further research is needed under a wider range of environmental conditions to confirm the usefulness of the above treatments. It appears likely that new, and perhaps as yet untried chemicals, used alone or in mixtures with our standard nursery herbicides may offer longer periods of contol of more species of weeds in the very near future.

[1] University of Wisconsin, Madison, Wisconsin.

TOLERANCES OF CERTAIN NURSERY STOCK TO CMU AND SES

L. C. Chadwick and P. A. Barker[1]

(Abstract)

To determine the tolerances of certain ornamentals, potted plants of 2-year old Norway spruce, Japanese maple, and flowering dogwood, 3-year old *Taxus cuspidata intermedia*, 4-month old *Forsythia intermedia spectabilis* (age from cuttings), and 2-month old marigold were treated with 1 to 4 applications of CMU, SES, or combinations of CMU and SES at respective rates of ½, 4, and ½ and 4 lb./A. The replicated plots contained 10 plants of each species of plant. Time lapse between each application was about 10 weeks. From half the plants in each plot, the excess water that leached from the pots was collected and returned to the pot soil weekly to compare the plants with those plants where the leachate was lost.

Results: In those plots where the treatment had included CMU, necrosis appeared on the foliage tips of the marigold within one week after the first application. Five weeks later all the marigolds in these plots were either killed or damaged severely. The marigolds in the plots treated only with SES remained the same as those in the check plots. Many of the leaf petioles of the flowering dogwood became twisted and the plants were eventually killed where the treatments had included SES. Prior to the second application, the flowering dogwood and marigold plants were discarded. With the remaining plant types no damage has appeared through the third application. No significant difference could be assessed where the leachate was returned to the pot soil.

[1] Ohio Agricultural Experiment Station, Wooster, Ohio.

CHEMICAL WEED CONTROL IN A *TAXUS* NURSERY

L. C. Chadwick, P. A. Barker, and W. D. Chambers[1]

(Abstract)

During 1955 tests were made in a field nursery of 5-year *Taxus cuspidata intermedia* at Columbus, Ohio, to determine the effectiveness of controlling weeds when in the germinating and seedling stages. On June 16 and August 4, plots 500 sq. ft. in size, replicated twice, were treated with the herbicides at rates given in the table below. All applications were made in water equivalent to 86 gal./A. Previous to each treatment all weed residue, resulting from cultivation and hand hoeing, was removed from the nursery. Moisture in the Brookston silt loam soil was near field capacity on August 4 but somewhat lower on June 16.

Visual evaluations of weed prevalence, made 4 and 6 weeks after each series of treatments, were averaged and computed in terms of broadleaf weed control as shown in the table below.

Treatment & rate, lb./A.	Treatment series June 16	Application date August 4
	% Weed control*	
CMU, ½	46	20
SES, 4	31	60
CMU, ½ plus SES, 3	31	86
CMU, ½ plus SES, 3	46	86
CMU, ½ plus SES, 4	75	96
	% Weed prevalence	
Check	60	50

* Weed control $= \frac{A - B}{A}$, where A = weed prevalence in check plots and B = weed prevalence in treated plots.

Quack grass, field bindweed, and Canada thistle were abundant in many of the plots and, except as indicated below, none of them was damaged nor suppressed by any of the treatments. These weeds, which originated from deep residual roots were disregarded in weed control evaluation. Of the weeds originating from seed following the treatments, pigweed and purslane were the most prevalent in all the plots and the figures presented in the table above are largely representative of the control of them. Best weed control was obtained in plots treated with CMU at ½ lb./A. plus SES at 4 lb./A. This latter treatment also damaged Canada thistle severely.

In another series of tests, plots 7 by 200 feet in size, each consisting of two rows of Taxus, were treated on June 25 and again on August 13 with SES, NP, and CIPC at the respective rates of 4, 5, and 7.5 lbs./A. Plot preparations and application techniques were similar to those listed above. No precise estimates could be made of the weed control following either treatment since weeds were unusually scarce in both the check and the treated plots. Neither the tops nor the roots of the Taxus were damaged by any of the treatments used in this experiment.

[1] Ohio Agricultural Experiment Station, Wooster, Ohio.

CHEMICAL CONTROL OF CRAB GRASS IN LAWNS, GOLF GREENS AND OTHER TURFGRASS AREAS

H. L. Lantz[1]

The following is a summary statement of the crab grass control studies at Ames from 1950 to 1955.

Crab grass in lawns, golf courses, athletic fields and other turf grass areas is capable of destroying the desirable blue grass sod. Recognizing this seriously increasing menace of crab grass, extensive studies in many states have been undertaken to devise effective methods of control.

At Iowa State College, studies in control have been underway since 1950. These studies have dealt with chemical controls. The area used was on a badly infested blue grass fairway of a local golf course. Plot size was 6' x 55' or approximately ⅓ of a thousand square feet.

There was considerable variation from season to season in the results obtained in treating crab grass infested turfgrass areas. Most chemical controls are more efficient when soil moisture is sufficient to maintain good growth of the desirable grass. Prolonged dry weather weakens the grass and certainly aggravates the amount and severity of burn following the application.

There are three seasonal periods of attack that will be discussed in this report.

1. Pre-emergence period; treatment prior to the germination of crab grass seed. At Ames crab grass seldom germinated before June 10.
2. Two leaf stage—about July 1 to 15.
3. Seed head stage—beginning in August depending on weather conditions.

(1) Pre-emergence tests. In 1955 there was clear cut evidence that each of the four pre-emergence treatments reduced the stand of crab grass as indicated in the table. No injury to the blue grass occurred on any of the plots. In 1956 it is planned to increase Crag Herbicide 1, to 2 or 2½ ounces per 1000 square feet per treatment.

Treatment	Rates per 1000	Dates of application	No. Plots	9-1-55 Crab grass count Average per sq. ft.
Check			6	16.5
Crag Herbicide 1	1.5 oz.	5/20—6/15—7/18	5	3.2
ACP L 842*	*2.25 oz.	5/20—6/16	2	2.8
ACP L 888*	*2.25 oz.	5/20—6/16	2	3.2
Alanap 1F	18 lbs.	5/20—6/16—7/18	5	2.3

* Mixed with 5 lbs. Milorganite. Applied with fertilizer spreader.

(2) Two leaf stage treatments. During four years of trials at Ames, crab grass has developed the two leafed stage during the first two weeks of July. Excellent control followed the use of several phenyl mercuric acetate compounds. These were PMAS and Tat-C-Lect. The rate used was 2½ ounces per 1000 square feet sprayed on with three gallons water plus spreader. Three to five applications about a week apart were sufficient.

Crab grass once established in a golf green is a serious weed. The use of 1 to 1¼ ounces of PMAS per 1000 square feet is generally recognized as a very efficient means of chemically controlling crab grass. At least three applications are needed, but in stubborn cases five applications may be necessary.

The disodium methyl arsonates. We have only the past season's results to report. The weather was exceedingly dry and hot during late July and August. Twenty plots, each 6 x 55 feet in size were treated. The arsonates were applied by power sprayer, at the rate recommended by the manufacturer. The spray dates were July 19 and 25. Severe burn followed these applications. The crab grass kill was 100 per cent in the methyl arsonate plots. In the plots treated with the benzyl arsonates, the control was excellent but an average of about 75 crab grass plants were counted per plot.

The methyl arsonates included Methar, Weedone and Crab-E-Rad. The benzyl arsonates in the tests were Benzar and Benzar 105.

(3) Seed head stage. Four years of treatments at Ames can be summarized briefly as follows.

Potassium cyanate spray (with spreader) applied at the rate of 4 ounces per 1,000 square feet, two applications, a week apart, reduced the stand of crab grass to as low as 5 per cent as compared with the untreated check plots. The blue grass was markedly "burned" but recovered normal color and growth in about 10 days.

Excellent results were also achieved by mixing powdered potassium cyanate with a granular organic fertilizer. The application was with spreader. The rate, four ounces potassium cyanate in 5 lbs. fertilizer applied to plots 6 x 55 feet in size. The interesting feature was that no "burning" or off color effects were observed following treatment. The control following two applications was equal to that secured by the spray applications.

SUMMARY:

Pre-emerge treatments appear to be worth further study. The results in 1955 at Ames indicate this. The value of the phenyl mercury compounds applied during the two leaf stage has been amply demonstrated. Potassium cyanate applied during the seed head stage of development will reduce seed production.

Where crab grass has "taken over" a turfgrass area, lawns in particular, drastic steps are necessary in order to restore a desirable turf. Our 1955 results with the methyl arsonates severely burned the treated plots and the lawns which were included in the tests, but this season's crab grass seed crop was destroyed. Rains in September brought the blue grass back rapidly and while showing some thinning out, was making a satisfactory recovery in all the plots and lawn areas treated.

A sensible fertilizer program to stimulate blue grass and build a firm, tight and resilient sod is definitely indispensable in restoring a weed infested turfgrass area.

[1] Iowa State College, Ames, Iowa.

STUDIES ON THE CONTROL OF CRABGRASS IN BLUEGRASS LAWNS[1]

R. E. Nylund and Richard Stadtherr[2]

The present paper is a report of four years' results with some crabgrass killers, and an attempt to explain variations in selectivity of some of them on the basis of the environmental conditions prevailing during these years.

Tests were conducted during the summers of 1950, 1951, 1954 and 1955 at University Farm in replicated plots on a large bluegrass lawn heavily infested with crabgrass (*Digitaria* spp).

Experimental Results

In 1950, eleven herbicides were applied as post-emergence treatments starting on July 13 when crabgrass was in the two-to-four leaf stage. Table 1 gives the estimated per cent control of crabgrass one week after the last herbicide application. Of the herbicides tested, only Stoddard solvent, kerosene, PMAS, and S-1998 gave good control of crabgrass and, of these, only the latter two caused no lasting injury to the bluegrass.

In 1951, seven herbicides were applied as post-emergence treatments starting on June 28 when crabgrass had two-to-four leaves. Table 2 gives the percentage of crabgrass control as obtained by counts in square foot areas in each replicate, and bluegrass injury ratings one week after the final herbicide application. Stoddard solvent at 40 and 60 gallons per acre gave excellent crabgrass control as did the 80 gallon rate in 1950, but the lower rates used in 1951 caused less bluegrass injury. PMAS, KOCN, and S-1840M also gave good crabgrass control but caused somewhat more bluegrass discoloration. One month after the herbicides were applied, no bluegrass injury was apparent in any of the plots.

Table 1—Crabgrass control and bluegrass injury resulting from the application of various herbicides, 1950.

Herbicide and acre rate applied [1]	Dates of application	On July 29: Crabgrass control per cent	Bluegrass injury [4]
0.8 lb. PMAS	7/13, 7/20	96	0
18.75 lb. S-1998[2]	7/13, 7/17, 7/21	96	0
80 gal. Stoddard solvent[3]	7/13	96	0.8
120 gal. Kerosene[3]	7/13, 7/20	84	1.0
8 lb. KOCN	7/13, 7/23	60	0
10 lb. TCA (Na. salt)	7/13	60	1.0
80 gal. Standard C.G. Killer[3]	7/13, 7/23	30	0.2
80 gal. L-2687	7/13, 7/23	24	0.2
160 gal. 0.3% MH	7/13	16	0
5 lb. DCU	7/13, 7/23	10	0
18.75 lb. S-1980[2]	7/13, 7/17, 7/21	10	0

[1] Active ingredient basis except in case of proprietary herbicides.
[2] Boronium flourides.
[3] Petroleum oils.
[4] 0=no injury; 5=bluegrass dead.

Table 2—Crabgrass control and bluegrass injury resulting from herbicide application, 1951.

Herbicide and acre rate applied [1]	Dates of application	On July 11: Crabgrass control per cent	Bluegrass injury [3]
60 gal. Stoddard solvent	6/28	91	0.2
40 gal. Stoddard solvent	6/28	83	0.2
0.5 lb. PMAS	6/28, 7/5	85	1.1
17.5 lb. S-1840M[2]	6/28, 7/5	85	1.0
8 lb. KOCN	6/28, 7/5	75	1.6
11.5 gal. S-2470[2]	6/28	66	0.8
1 lb. Sodium arsenite	6/28, 7/5	52	1.8

[1] Active ingredient basis except in case of proprietary herbicides.
[2] Boronium flourides.
[3] 0=no injury; 5=bluegrass dead.

In 1954, four pre-emergence and three post-emergence herbicides were applied. The pre-emergence treatments were begun on June 8, approximately three weeks prior to first emergence of crabgrass in the experimental area; the post-emergence treatments were begun on July 7, one week after the first crabgrass emergence. Table 3 gives the percentages of crabgrass control obtained, based on actual counts, and the ratings of injury to bluegrass. All herbicides except Standard Crabgrass Killer and PAX significantly reduced crabgrass stands. KOCN was the most effective crabgrass killer followed by PMAS and Alanap.

In 1955, seven pre-emergence and six post-emergence herbicides were included in the crabgrass control trial. The pre-emergence treatments were begun on June 10 when a few small crabgrass plants were visible in the plot area. The post-emergence treatments were begun on June 24 when crabgrass plants were in the 3-4 leaf stage. The two oils, Standard Crabgrass Killer and Standard Spray C were applied first on July 22 when crabgrass was in the "boot" stage. Table 4 gives the crabgrass control and bluegrass injury data obtained on these dates with the various treatments. Of the post-emergence treatments, PMAS and disodium methylarsonate gave excellent control two weeks after the last application. However, a month later considerable regrowth of crabgrass had occurred. Standard Spray C gave 76% control of crabgrass two weeks after it was applied at the "boot" stage. All of the post-emergence treatments in 1955 caused considerable bluegrass discoloration. Of the pre-emergence treatments, only sesin gave a fair measure of crabgrass control (76%) after two applications. One month after the third application, it was still the best pre-emergence treatment but gave only 50% control and showed the greatest degree of bluegrass injury.

Discussion

The extreme variations in temperature and moisture conditions during the four years of testing make it possible to determine the extent to which weather conditions influenced herbicide effectiveness, and bluegrass injury.

Table 3—Crabgrass control and bluegrass injury with various pre- and post-emergence herbicides, 1954.

Herbicide and acre rate applied [1]	Dates of application	On Aug.3: Crabgrass control per cent	Bluegrass injury [3]
8 lb. KOCN	7/7, 7/14	97	0.2
0.5 lb. PMAS	7/7, 7/14	75	1.0
107 gal. St'd. C.G. Killer	7/7, 7/22	41	4.0
8 lb. Alanap	6/8, 7/6	75	1.2
8 lb. SES	6/8, 7/6	66	0
15 lb. Chlordane (in oil)	6/8, 7/6	66	0
2178 lb. PAX (dry)[2]	6/8	53	1.0

[1] Active ingredient basis except in case of proprietary compounds.
[2] Contains 13.2% lead arsenite and 3% nitrogen.
[3] 0=no injury; 5=bluegrass dead.

Table 4—Crabgrass control and bluegrass injury with pre- and post-emergence herbicides, 1955.

Herbicide and acre rate applied [1]	Date of application	On July 22: C. G. control per cent	On July 22: B. G. injury [4]	On Aug. 23: C. G. control per cent	On Aug. 23: B. G. injury [4]
0.9 lb. PMAS	6/24, 7/1, 7/8	100	3.0	56	2.5
8 lb. Disod. methylarsonate	6/24, 7/1, 7/8	96	3.5	44	3.0
8 lb. KOCN	6/24, 7/1, 7/8	70	2.2	20	1.2
653 lb. Milcyanate (dry)[2]	6/24, 7/1, 7/8	56	3.0	6	2.2
108 gal. St'd. Spray C[3]	7/22, 8/5	—	—	76	3.0
108 gal. St'd C.G. Killer	7/22, 8/5	—	—	16	3.0
8 lb. Sesin	6/10, 7/1, 7/22	76	2.0	50	2.2
784 lb. Alanap 1F (dry)	6/10, 7/1, 7/22	60	0	40	2.0
4 lb. Naugatuck 3Y9	6/10, 7/1, 7/22	60	1.0	30	1.2
4 lb. DuPont No. 1	6/10	56	1.0	6	1.0
10 lb. DCU	6/10	44	1.2	30	1.2
8 lb. SES	6/10, 7/1, 7/22	30	0.2	20	0
6 lb. CDEA	6/10	0	0	0	0

[1] Active ingredient basis except Milcyanate and Aalanap 1F.
[2] 4% KOCN and 96% Milorganite.
[3] Petroleum oil containing chlordane.
[4] 0=no injury; 5=bluegrass dead.

Association between environmental variables and crabgrass control varied with the herbicide applied in the present study. PMAS gave the best crabgrass control under moderately cool, moist conditions (1950); was somewhat less effective under cool, dry conditions (1951); and was least effective under the hot, dry conditions following herbicide application in 1954 and 1955. KOCN, on the other hand, gave the best crabgrass control under the hot, dry conditions of 1954 but the poorest control under similar conditions in 1955.

Both herbicides caused the greatest injury to bluegrass under the hot, dry conditions of 1955, somewhat less injury under similar conditions in 1954 and under the cool, dry conditions of 1951, and no injury under the moderately cool, moist conditions prevailing in 1950. An adequate supply of moisture following the application of either PMAS or KOCN appears to be more important than low temperatures in reducing turf grass injury.

Summary

1. Over a period of four years, twenty-six herbicides were tested for their effectiveness in controlling crabgrass in a bluegrass lawn. Two of these herbicides—potassium cyanate (KOCN) and phenyl mercuric acetate (PMAS)—have been tested in all four years.

2. Two to three applications of KOCN applied at eight pounds per acre after emergence of the crabgrass killed an average of 76 per cent of the crabgrass present.

3. Two to three applications of PMAS applied at 0.5 to 0.9 pounds per acre killed an average of 89 per cent of the crabgrass plants present.

4. Other herbicides which have given fair to good crabgrass control but which have not been as thoroughly tested include Stoddard solvent, various boronium flouride formulations (S-1998, S-184OM, S-2470), Alanap, disodium methylarsonate, chlordane in a petroleum oil (Standard Spray C,) and sesin.

5. Toxicity of KOCN and PMAS to crabgrass was not as closely associated with environmental factors as was their toxicity to bluegrass. Both high temperatures and drought were associated with increased injury to bluegrass.

[1] Abstract of Paper No. 3466 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.
[2] University of Minnesota, St. Paul, Minnesota.

WEED CONTROL IN TRANSPLANTED TOMATOES

G. F. Warren[1]

Research workers in the northcentral and northeastern states have reported large differences in the tolerance of transplanted tomatoes to Natrin (sodium 2,4,5-trichlorophenoxy ethyl sulfate) under various conditions. In order to study the response of weeds and tomatoes to this herbicide in Indiana, experiments were conducted on a silt loam soil in 1954 and 1955. Another herbicide, DCU (dichloral urea), was also included in most of the trials.

Georgia-grown Rutgers tomato plants were transplanted between May 20 and June 8 and the herbicides applied either three or four days later in 50 gallons of water per acre. Plots consisted of single rows of 24 plants, two feet apart in the row, with 80 inches between rows. There were four replications except as noted later. In 1954 1.40 inches of rain fell in the two weeks following spraying while in 1955 from 2.45 to 2.99 inches fell in the two weeks after treatments were applied in the three experiments conducted that year.

Table I shows the weed counts taken one month after spraying in one of the experiments. It is apparent that DCU was highly effective in controlling crabgrass (*Digitraia sanguinalis*) and foxtail (*Setaria* spp.). It did not control carpetweed (*Mollugo verticillata*) or ragweed (*Ambrosia artemisiifolia*). The major weakness of Natrin was in foxtail control at the two-pound rate. Weeds were removed by hoeing and cultivation throughout the remainder of the season in all experiments.

In 1954 tomatoes showed slight stunting from four pounds of Natrin and considerable stunting from eight pounds. DCU caused no apparent injury at the lower rate but with 15.2 pounds there was some stunting and chlorosis of the foliage. The yields are shown in Table II. In 1955 yields were low due to hot, dry weather and the wide row spacing (Table III). No injury was observed from any of the treatments but in Experiment III, where eight replications of double-size plots were used, the reduction in yield with four pounds of Natrin was highly significant.

In one experiment each season, treatments were also applied to previously unsprayed plants two to four weeks after transplanting. These delayed applications showed no inury to the tomatoes but were entirely ineffective in controlling weeds. Most of the weeds germinated early and the delayed treatments did not control them since they were well established when these sprays were applied.

Both Natrin and DCU appear promising for control of weeds in transplanted tomatoes under the conditions studied. Natrin controlled more weed species but the margin of safety for tomatoes was small when applied within a few days after transplanting. Two pounds per acre was a little low for weed control while four pounds caused slight injury in some cases. DCU at four to eight pounds per acre gave excellent annual grass control. It had the advantage over Natrin in a greater margin of safety for the crop but lack of control of most broad-leaved weeds present was a definite weakness. In the experiments reported here, where annual grasses made up a major portion of the weed population, DCU appeared especially promising.

Table I.
Weed Control in Transplanted Tomatoes—1955

		No. weeds per sq. ft.			
Herbicide	Lbs./A.	Crabgrass	Foxtail	Carpetweed	Ragweed
Check	—	9.9	10.4	10.8	.15
DCU	4	2.9**	2.5**	13.4	.16
DCU	8	.6**	1.8**	11.5	.18
Natrin	2	2.8**	7.9	.7**	.07*
Natrin	4	1.4**	3.7*	.2**	.02**

* and ** significantly lower than check at the 5% and 1% levels respectively.

Table II.
Marketable Yield of Transplanted Tomatoes—1954

Herbicide	Lbs./A.	Yield in Tons/A.
Untreated	—	10.0
DCU	7.6	10.6
DCU	15.2	8.9
Natrin	4	9.3
Natrin	8	7.6
	L.S.D. 5%	1.7
	1%	2.3

Table III.
Marketable Yield of Transplanted Tomatoes—1955

		Yield in Tons/A.		
Herbicide	Lbs./A.	Exp.I	Exp.II	Exp. III
Untreated	—	4.0	7.5	6.3
DCU	4	5.0	6.4	—
DCU	8	5.2	7.5	—
Natrin	2	5.2	6.6	—
Natrin	4	4.7	6.9	5.0**
	L.S.D. 5%	N.S.	1.1	—

** Significantly lower than check at the 1% level.

[1] Purdue University, Agricultural Experiment Station, Lafayette, Indiana.

THE POST-EMERGENCE APPLICATION OF HERBICIDES TO TOMATOES AT DIFFERENT TIMES AND LOCATIONS[1]

by S. K. Ries[2] and B. H. Grigsby[3]

No herbicide has, as yet, been recommended for use in tomatoes on other than a trial basis. Research workers through the years have reported varing success with Crag Herbicide (2,4-dichlorophenoxyethyl sulphate), Sesin (2,4-dichlorophenoxy ethyl benzoate), CMU-W (3, p-chlorophenyl 1-1 dimethyl urea) and Natrin (Na 2,4-5 trichlorophenoxyethyl sulfate) (1, 2, 3, 4, 5, 6, 7, 8, 9). Natrin has been recommended for trial use in some states.

The objectives of this work, conducted in 1955, were to determine: 1) if either CMU, or Natrin would continue to give good weed control without injuring the tomatoes as in 1954 (6), (2) if Methin (Sodium 2 Methyl 4-chlorophenoxyethyl sulfate) was a good herbicide for tomatoes, (3) the best time and rate of application for the three chemicals, 4) if there is a difference in response at different locations.

XUM

MATERIALS AND METHODS

A split plot factorial design with three replications was utilized. The largest division was for locations which were: (1) East Lansing, located in the central portion of the state and (2) Sodus, located in southwestern Michigan. The next division was chemicals and rates, and the smallest split was for time of application. The variety used at both locations was Rutgers.

The soil at East Lansing was a Hillsdale light sandy loam. The soil at Sodus was an Oshtemo sandy loam. The plants were spaced three feet apart in the row. There were eight plants harvested per plot at East Lansing and five plants harvested per plot at Sodus.

Some weeds were in the cotyledon stage at both locations when the first treatments were applied, May 30 and 31. All plots were cultivated and carefully hoed prior to the applications made at lay-by, June 29 and July 8. At this time, the first fruit clusters were set and the plants were in full bloom. Conditions were considered ideal for weed control at both times and for both locations. The plots were irrigated with one inch of water at Sodus at the time the lay-by treatments were applied to provide a moist soil. Weed control ratings were made and the weight of marketable tomatoes was recorded for each plot.

Table 1—Yield and weed control from post-emergence application of herbicides applied at two different times at two locations on tomatoes.

Treatment	Rate lbs./acre	Weed Control Rating [1]	Yield tons/acre
None		1.5	18.51
Natrin	2	3.9	14.30
Natrin	4	6.7	11.78
Methin	2	5.1	14.45
Methin	4	7.1	12.05
CMU	½	7.2	14.03
CMU	1	8.0	11.60
L.S.D. at 5%		1.3	2.98
L.S.D. at 1%		1.7	4.02
Coefficient of Variability		26.2%	17.4%

[1] Weed Control Rating 1 = no control, 6 = commercial control, 9 = eradication.

Table 2—The yield of tomatoes, in tons per acre, from the various treatments applied at different times at two locations.

Treatment	Rate lbs./acre	East Lansing After transplanting	East Lansing at lay-by	Sodus After transplanting	Sodus at lay-by
None		16.8	16.8	11.0	11.0
Natrin	2	13.9	13.8	8.7	6.4
Natrin	4	10.5	13.2	9.1	2.4
Methin	2	13.0	13.6	8.4	8.2
Methin	4	10.8	10.7	9.6	5.1
CMU (W)	½	11.7	10.8	8.1	11.4
CMU (W)	1	7.1	11.1	8.2	8.4

RESULTS

The predominent weeds in plots at both locations were purslane (*Portulaca oleracea*), lamb's quarter's (*Chenopodium album*), pigweed (*Amaranthus retroflexus*), ragweed (*Ambrosia artemisiifolia*) and crabgrass (*Digitaria sp.*). The analysis of variance for weed control ratings indicated that of all the main effects and interactions studied only the main effect of treatments was significant. These ratings are presented in Table 1. Excellent weed control was obtained from four pounds per acre of Natrin and Methin. Both ½ and 1 pound of CMU (W) gave good weed control.

The summary of treatment yields in Table 1 shows that all of the treatments reduced the yield of marketable tomatoes. Tomatoes responded similarly to the treatments at both locations. In general there was no difference between the two times of application, and all treatments responded similarly at both times of application.

Table 2 illustrates that treatments applied after transplanting were more injurious than later treatments at East Lansing, while the reverse was true at Sodus.

Table 3—The yield of tomatoes in tons per acre from plots treated at two different times at different locations.

Location	Chemicals applied after transplanting	Chemicals applied at Lay-by
Sodus	15.24	10.29
East Lansing	16.08	17.04

The significance of the second order interaction of treatments x locations x time was due to a reduction in yield caused by certain treatments at one location but not the other. Table 3 gives the yields from the various treatments applied at different times at two locations. Note that the only treatment which compares favorably with the check is ½ pound per acre of CMU (W) applied as a lay-by treatment at Sodus.

SUMMARY

Under the conditions of this experiment, the following was determined:

1. Four pounds per acre of Natrin, four pounds of Methin and one-half and one pound per acre of CMU (W) controlled weeds effectively in tomatoes at both times of application and both locations.
2. All of the herbicides tested reduced the yield of tomatoes at the rates used.
3. All treatments in general reduced the yield at both locations and at both times of application.
4. CMU (W) at one-half pound applied at lay-by at Sodus caused no reduction in yield.
5. The results of this work and reports of other workers indicate that there is too much injury caused by the herbicides used in this test to make them practical for commercial use in tomatoes.

LITERATURE CITED

1. Ferguson, W. and J. J. Jasmin.
Chemical Weed Control in Onion, Squash and Tomatoes. Proc. 9th Annual NEWCC 1955. pp. 169-175.
2. Menges, Robert M., and Richard J. Aldrich.
A Comparison of Crag, Derivities of Crag, and CMU for Pre-Emergence Weed Control in Tomatoes. 8th Annual Proc. NEWCC 1954, pp. 137-143.
3. Menges, Robert M., and R. J. Aldrich.
The Responses of Tomatoes to Natrin and Derivitives as Affected by Time of Application and Irrigation. Proc. 9th Annual NEWCC 1955, pp. 121-126.
4. Noll, Charles J., and Martin L. Odland.
Chemical Herbicides as they Affect Yield of Tomatoes. 8th Annual Proc. NEWCC, 1954. pp. 191-192.
5. Ries, S. K., and R. D. Sweet.
Post-Emergence Application of Certain Esters of 2,4-dichlorophenoxyethanol on Tomatoes. Proc. NEWCC 1953, pp. 103-107.
6. Ries, S. K. and B. H. Grigsby.
Post-Emergence Application of Herbicides on Tomatoes. 11th Annual Proc. NCWCC 1954, pp. 79.
7. Sweet, Harold A., and E. R. Marshall.
Post-Setting and Lay-By Applications of Herbicides to Canning Tomatoes in Western New York. Proc. 9th Annual NEWCC 1955, pp. 115-119.
8. Sweet, R. D., Garvin Crabtree and Chauncy Benedict.
Herbicides for Tomatoes. 9th Annual NEWCC 1955. pp. 141-149.
9. Zedler, R. J.
Progress Report on the Use of Experimental Herbicide Natrin 80S in Tomatoes. 9th Annual Proc. NEWCC 1955, pp. 127-130.

[1] Journal Article 1856 of the Michigan Agr'l. Experiment Station.
[2] Assistant Professor, Department of Horticulture, Michigan State University.
[3] Professor, Department of Botany and Plant Pathology, Michigan State University.

XUM

ELIMINATION OF VEGETATION WITH TCA AND DALAPON

L. C. Chadwick and W. D. Chambers[1]

Replicated plots containing between 200 and 500 sq. ft. and overgrown with volunteer vegetation consisting mainly of green foxtail, Johnson grass, German millet, quack grass, crabgrass, dandelion, Canada thistle, gum weed, alsike clover, pigweed, smartweed and plantain were treated with the herbicides given below on May 26 and August 19. Applications were made in water equivalent to 86 gal./A. The vegetation was cut to the ground between the first and second application. Visual evaluations were made three weeks after the May 26 treatment and five weeks after the August 19 treatment.

RESULTS

Dalapon at 10 and 20 lb./A. gave 90% control of broadleaf weeds and resulted in browning and retardation of top growth on the grasses. For three to five weeks after treatment no new vegetative plants came into approximately half of the treated areas. Sodium TCA at 20 and 35 lb./A. gave very little control of broadleaf weeds but approximately 85% control of grasses. Plantain was not controlled by either TCA or Dalapon. There was no injury to *Euonymus fortuni vegetus* after direct application of TCA at 20 lb./A. and TCA and Dalapon caused considerable twisting and defoliation on *Lonicera korolkowi zabelli* but not death. Wind drift of TCA and Dalapon caused no injury on *Sophora japonica, Philadelphus virginalis,* and *Laburnum anagyroides* and slight browning on *Acer platanoides.*

Dalapon at either rate is considered better than TCA at either 20 or 35 lb./A.

1 Ohio Agricultural Experiment Station, Wooster, Ohio.

EFFECTS OF 2,4-D ON CONCORD GRAPE[1]

E. W. Scholz, W. E. Loomis, and H. L. Lantz[2]

Use of volatile formulations of 2,4-D in Iowa have been so extensive that the atmosphere in recent summers has been charged with enough material to cause morphological deformities of grape shoots. The general occurrence of uneven ripening of and within bunches and the advent of a second set of fruit has been thought to originate from this contamination. A study was made to determine the effects of 2,4-D on the Concord grape and thereby to determine how seriously this contamination may threaten the grape growing industry.

Concord grapes were observed which were exposed to ambient 2,4-D which contaminated the summer atmosphere beginning the first two weeks of July. Other plants were treated with spray concentrations and specific amounts of 2,4-D.

Ambient 2,4-D caused morphological leaf damage. It is not conclusive whether or not it is the cause of reported uneven ripening and second crop set of fruit; however, these effects were obtained with 2,4-D sprays.

Sprays with a concentration of 100 ppm 2,4-D acid equivalent applied before flowering, reduced fruit set from 27.6 per cent to four per cent. Leaf area on both 10 and 100 ppm treatments was greatly reduced; plants thus treated survived, however, and made rapid recovery.

Sprays of 10 ppm applied July 10 caused uneven ripening of the fruit. Sprays of 100 ppm caused delay of maturity and a complete loss of crop resulted. Neither 10 nor 100 ppm treatments reduced foliage appreciably.

Sprays of 2,4-D applied at harvest time caused no immediate symptoms. About four weeks after the breaking of the buds the following spring, plants sprayed with 100 ppm 2,4-D before dormancy developed severe 2,4-D symptoms; results were reduced fruit set on a four-year-old plant and a significant reduction of sugar content of grapes on 24-year-old vines.

Translocation of 2,4-D activity was observed to be limited to the treated shoot if application was made early in the growing season.

1 Journal Paper No. J-2876 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1109.
2 Iowa State College, Ames, Iowa.

SOIL STERILIZATION WITH VAPAM AND SODIUM CHLORATE

L. C. Chadwick, P. A. Barker, and W. D. Chambers[1]

(Abstract)

Soil sterilization for the purpose of eliminating all vegetative growth was done in unplanted lath house beds and field areas where container nursery stock was to be placed. Used in the tests were sodium chlorate and Vapam 4-S, a soil fumigant solution of sodium N-methyl dithiocarbamate (anhydrous). Treatments were made during May, 1955, after the areas had been clean cultivated. In nursery #2, sodium chlorate was applied with the use of a hydraulic sprayer at the rate of one pound in two gallons of water per 100 sq. ft. Elsewhere the sodium chlorate and all the Vapam 4-S was applied through a watering hose equipped with a Hozon at the faucet and a "rose flare" at the unattached end. By this method the respective herbicides were mixed with 16 gal. of water to every 100 sq. ft. of surface area. Part of the area treated with Vapam 4-S or sodium chlorate was covered with 1½ inches of crushed limestone following application of the herbicide.

To assess the resulting weed populations, weed counts were made in the lath house and visual estimates were made elsewhere. All areas were free of vegetation for at least four weeks after treatments. Weed control six to eight weeks after treatment are given below.

Plot location and surface treatment	Treatment	Rate, per 100 sq. ft.	% Weed control* Broad-leaves	% Weed control* Grasses
Lath house, not graveled	Vapam 4-S	1 pt.	72	91
Lath house, not graveled	Vapam 4-S	2 pt.	91	100
Nursery #1, graveled	Vapam 4-S	2 pt.	—	90
Nursery #1, graveled	None	—	—	30
Nursery #1, graveled	Sodium chlorate	1 lb.	—	65
Nursery #1, not graveled	Sodium chlorate	1 lb.	—	45
Nursery #2, not graveled	Sodium chlorate	1 lb.	0	0

* Weed control $= \frac{A - B}{A}$ where A = weed prevalence in check plots and B = weed prevalence in treated plots.

out the areas where Vapam was used. Neither a layer of gravel nor sodium chlorate was suitable.

1 Ohio Agricultural Experiment Station, Wooster, Ohio.

XUM

WILDLIFE HABITAT DEVELOPMENT WITH HERBICIDES IN MICHIGAN

B. C. Jenkins[1]

We have not solved the problem of wildlife habitat development in Michigan by using herbicides. But we have been giving the herbicides a good try on the premise that any reasonable means of controlling vegetation ought to be tried. The right amount and distribution of various kinds of vegetation makes good wildlife habitat. This condition occurs during the young stage in the development of a forest. Mother Nature, however, is not static and she seems intent on recreating the wilderness on the four million acres of state-owned land in Michigan.

The purpose of this paper is to present some of the problems of wildlife habitat management that herbicides may help to solve; to outline briefly the field tests made in Michigan; and to encourage the development of even more effective herbicides and better methods of using them.

Northern Michigan, as considered here, consists roughly of the north half of the Lower Peninsula and the Upper Peninsula. Deer, black bear, ruffed grouse, snowshoe hare, sharp-tailed grouse, squirrels, and waterfowl are the primary game species. None of them except possibly the squirrels do well in large, heavily forested areas.

Sharp-tailed Grouse

Our first aerial spraying test was made in August 1952 to create additional open area for sharp-tailed grouse. The theory that the growth substance herbicides would kill woody vegetation roots and all indicated that, even though more costly than controlled burning, the treatment would last enough longer to make it worth while. Accordingly 600 acres of fairly thick aspen was sprayed in cooperation with the Dow Chemical Company.

Fairly good top-kill was obtained but a good deal of aspen sprouting occurred during the next two growing seasons. This was a disappointment until we became aware that deer, hard-pressed for food were making good use of the succulent sprouts.

Now, we are resigned to the necessity of repeat sprayings to create or maintain open areas for sharp-tails where aspen is the problem. Five different areas totaling about 1,600 acres have been sprayed by air for this purpose to date. In addition 210 acres have been treated by ground spraying.

Deer

Habitat management for deer in Michigan is one of our most pressing problems. Timber cutting is by far the best management tool we have. Deer feed on the tree tops felled as well as on the regrowth which follows. But timber sales do not apply to large areas of aspen which does not grow to merchantable size or quality because of poor site conditions.

During the past two summers ten areas of aspen totaling 340 acres near deeryards have been sprayed for the purpose of producing sprouts for deer. The results so far observable are not as good as controlled burning for sprout production but we can spray by air at times and on sites that can not be burned.

Waterfowl

A problem in connection with flooding projects for waterfowl is the growth of solid stands of marsh grasses that persist where the backwater is shallow. Dalapon sprayed by air appears to have promise.

Other Northern Michigan Game Species

While major trials of herbicides for habitat development in Michigan have been made for deer and sharp-tailed grouse, tests have also been made using hormone type herbicides both by air and from the ground to maintain or create small openings for ruffed grouse. Last summer we even attempted to aerial spray 40 half-acre spots for woodcock in one area where aspen had become too thick.

In southern Michigan there are 66 state game and recreation areas containing over 200,000 acres of state-owned land. These areas are located within easy driving distance of the most populous area of the state. The demand for hunting opportunity is great and our efforts to produce more small game for the bag by habitat development are being threatened by encroaching brush and tree growth.

Farm-Game

During the summer of 1954 a high pressure spray rig on a truck was kept busy from late June to early September spraying the fringes of small openings, the borders of old fields and access trails. In all, 432 acres were sprayed on eight game areas.

The effectiveness of the ground spraying encouraged further efforts and 600 acres were sprayed on fifteen game areas this past summer, 1955. In addition, 510 acres inaccessible to ground equipment was sprayed by air.

Other Problems

We have tried TCA and Dalapon applied in the fali to prepare planting sites in lieu of scalping. In the case of quack grass such treatment seems to be of value even though machine planting is to be used. The herbicide applied in bands 18 to 20 inches wide is effective long enough to allow the planted seedling to become well-established.

Dalapon applied in the fall followed by seeding in the spring with a grassland seeder promises to simplify the establishment of improved meadows and food patches for wildlife without the temporary absence of cover caused by plowing.

Control of vegetation is a basic necessity to good wildlife management. The herbicides with improved techniques may well become one of our most valuable tools.

1 Michigan Department of Conservation, Lansing, Michigan.

CONTROL OF UNDESIRABLE PLANTS IN WATERFOWL PROJECTS

R. A. MacMullan and E. M. Harger[1]

The Michigan department of Conservation is actively engaged in a program to create and improve waterfowl habitat by construction of dams to flood strategic locations. Usually these floodings cover large sedge (*Carex* and *Scirpus*) meadows, or dense stands of leatherleaf (*Chamaedaphne calyculata*) and associated shrubs. Openings in these dense stands would make the projects more efficient duck producers.

To determine the best methods for creating openings in dense sedge or leatherleaf, a series of preliminary experiments involving plowing and 11 different chemical treatments was started in 1950 by H. J. Miller, in charge of waterfowl management for the Game Division. These were evaluated by DiAngelo (1951). In 1953 another series of experiments was begun and is still continuing. All were done in the northern lower peninsula. This paper is a brief summary of what we have learned to date.

Plowing

Plowing has been tried in three flooding projects. When the sod was turned completely over, the sedge was discouraged sufficiently that new aquatics could take

XUM

hold. Even if the sod is not flooded, sedge is slow to re-establish itself.

Burning

In the summer of 1953 a portion of a leatherleaf bog was burned. It was difficult to get a good fire going but occasionally the fire would "crown," and severely burn small platches. Flooding after the fire was unavoidably delayed. Nevertheless, some desirable small openings were obtained. We have the impression that if flooding had occurred shortly after the fire, resprouting would have been inhibited. Under proper conditions, sedge can be burned. Vigorous resprouting is likely to occur, however. We have not yet attempted to flood sedge sod immediately after burning.

Application of Ammate on Leatherleaf

Leatherleaf has a reputation for being resistant to most herbicides. Preliminary experiments in 1953 showed hormone type chemicals and sodium arsenite to be from 25 to 65 per cent effective on leatherleaf. Ammate, however, provided complete kill, (Boyce, *et al.*, 1953) with no resprouting to date.

In the summer of 1955, four 1/250-acre plots of solid leatherleaf were sprayed with solutions of ¼, ½, 1, and 2 pounds of Ammate per gallon, in sufficient quantity to wet the leaves thoroughly—about one gallon per plot. By fall all plots appeared to have suffered complete kill, except the ¼-pound plot, where a few plants showed some life. Confirmation of this kill must wait until the 1956 growing season.

Application of Dalapon on Sedge

In July 1954, Dalapon was applied from the ground on a dense stand of sedge. Five different concentrations ranging from 10 to 50 pounds per acre were sprayed on mil-acre plots. The experiment was repeated in triplicate and control plots were established.

The following spring the site was flooded with about 15 inches of water. At that time all sprayed plots showed almost complete kill, while the sedge in the control was still growing vigorously. There was still no sign of sedge growth in the fall of 1955—15 months after spraying. We assume that ten pounds of Dalapon per acre, applied in a drench, will provide virtually complete kill.

In the summer of 1955, Dalapon was sprayed from the air under six different conditions (see Table I). Three of the experiments were done on a sedge sod which we expect to flood in the spring of 1956, and three were done on a sedge stand growing in from one to two feet of water. This latter stand of sedge has been stable for at least 15 years.

On plot No. 6, a duplicate of plot No. 5, the sedge was hand-mowed one month before the application. By the fall of 1955, most of the sedge on all six plots appeared to be killed. More exact appraisal of how well each solution worked must wait, however, until the growing season of 1956.

In the summer of 1954, three pounds of Dalapon salt (unmixed with water) was placed in a small spring-fed stream of about ¼ cu. ft. per second flow, flowing through a sedge meadow. We speculated that the dissolved Dalapon might kill some sedge, creating an opening along the stream edge. No evidence of sedge mortality could be observed. Although some sedge must have been covered with lethal concentrations of Dalapon, the washing action of the flow must have removed it before it could act.

Conclusions

Leatherleaf can sometimes be controlled by burning. Ammate provides good kill. A concentration of ¼ pound per gallon applied at 250 gallons per acre appears to be a lethal dose. Smaller concentrations may be effective.

Sedge can be burned. Plowing, where it can be done, will destroy sedge sod if the sod is turned completely over. Ten pounds of Dalapon per acre applied as a foliage drench yielded 100 per cent kill. Dalapon applied from the air at 15 pounds in 15 gallons of water per acre appeared to be effective. Possibly even smaller amounts would be effective. Final evaluation of the aerial application of Dalapon will be made in 1956. Aerial application of Dalapon can be done cheaply and can be used where fire or mechanical equipment cannot be used.

Although it is not always absolutely necessary, it is recommended that sites be flooded shorly after treatment.

Table I.

Aerial Application of Dalapon on Sedge Meadow.

Plot No.	Acres	Pounds per acre	Gallons per acre
1-F	1.2	30	42
2-F	1.2	30	7
3-F	1.2	10	21
4-UF	2.0	30	30
5-UF	2.0	15	15
6-UF	2.0	15	15

F—Flooded. UF—Unflooded.

Bibliography

Boyce, A. P., S. DiAngelo, B. Jenkins, and H. Miller, 1953. *The Experimental Use of Herbicides to Control Game Cover Succession in Northern Michigan.* Michigan Department of Conservation, Game Division Report No. 1194 (unpublished.)

DiAngelo, S. 1951. *A Preliminary Study of Waterfowl Flooding Projects in Region II.* Michigan Department of Conservation (unpublished.)

[1] Houghton Lake Wildlife Experiment Station, Michigan Department of Conservation, The Heights, Michigan.

SOME BIOLOGICAL, TECHNICAL AND ADMINISTRATIVE ASPECTS OF AQUATIC WEED CONTROL IN MINNESOTA

Edward J. Longtin[1]

Aquatic plants are not "weeds" in the same sense that terrestial plants are weeds. Dense beds of aquatic plants growing or in locations where they obstruct boating or swimming, or make fishing difficult, still can play an important part in the total ecology of the body of water concerned. It is well known that weedy areas in a lake produce many times more food for the fishes than bare open areas. It appears that a certain amount of aquatic plants are needed for the best survival of eggs and young fishes to maintain a fish population in a lake. However, there is a high degree of coincidence between the excessive growth of aquatic plants and overabundant and stunted panfish populations in lakes. This suggests that some types of population control of fishes may indirectly be conducted through the control of aquatic plants.

The above facts, and many others, must be considered in making decisions on control projects on individual lakes. Unfortunately, large areas of unexplored knowledge still remain concerning the basic ecological relationships between plants and animals in the aquatic environment and the effects of plant control on the total environmental complex. Decisions must be made on the limited facts known, and we attempt to keep the errors on the conservative side.

Aquatic plant control involves three separate and distinct phases. They are: (1) control of submergent plants; (2) control of emergent plants; and (3) control of algae. The control of algae with copper sulphate is well known and has been used for many years. Presently, some new chemicals are being tested and others

XUM

will probably be found in the future for adaptation to this type of control work. We in Minnesota hope to enter this testing and development program as rapidly as possible. We feel that, while some chemicals may provide good control in general use, other chemicals may be better suited to special cases that now are sometimes hard to handle.

Submerged aquatic plants have been controlled with sodium arsenite for some time. Until the past year, this control method was not used in public waters in Minnesota. Sodium arsenite is the only chemical we recommend for control of submerged aquatic plants, as it is the only chemical tested and proven through use. Because of its dangerous nature, we require that it be applied by qualified commercial sprayers.

Here again there is room for development of new chemicals or new uses for present chemicals. Under present regulations, the cost of control on small areas is prohibitive and not practical from a commercial basis. Yet, many requests for control involve small plots of 100 feet or less. The private party cannot afford the necessary rates for such work, and the commercial operator hestitates to take such work as the results are highly dubious at best.

The control of emergent aquatic plants presents more problems in that there is no chemical satisfactory for general use in this work. As a wide range of broad and narrow leaf plants fit in this category, it is possible that two or three chemicals may be needed for this work. The chlorinated phenoxyacetic acids have been used on these plants, but some of the results have been contradictory. Dichloropropionic acid shows great promise in cattail control. But the grasses, sedges, bulrush and waterlily present control problems not yet solved.

Most, if not all, of the herbicides in use or under development have been formulated for use on terrestial plants. Many of the compounds found most suitable for use as sequestering agents and vehicles in terrestial work are toxic to fishes or other aquatic animals. Some of these compounds, and the control chemicals also, are not toxic but can be absorbed by fish resulting in an off-flavor making the fish unfit for table use.

With the exception of algae control and the use of sodium arsenite, most of the aquatic plant control work that has been conducted involved special problems or projects conducted by conservation agencies interested in improving their physical installations or eliminating conditions that interfere with efficient operations. Sometimes the chemicals and methods of application were borrowed from terrestial control work and were not entirely adaptable to aquatic control work.

To have a well rounded program there must be proper direction and control. In Minnesota the Commissioner of Conservation has, by legislative act, been given the administrative and regulative control of any aquatic plant control program that may develop. A Commissioner's Order, dated 1945, prohibits the destruction of aquatic organisms except as permitted by the Department. Further exceptions are: hand cutting or raking on swimming areas or boat channels; cutting for temporary shooting or observation blinds; and etc. The object of the present regulations is the prevention of wholesale destruction of aquatic plants to the detriment of other aquatic organisms. As the present regulations are quite general in scope, it is possible that they will not completely fulfill this purpose. The past season's experience has taught us the necessity of controlling not only the destruction of plants, but also the methods used and exercising some control over the persons or companies doing this type of work. Most of the spray equipment used in agriculture work is adaptable to aquatic work. With the large amount of such equipment privately owned, it is possible that many persons would try to get into the aquatic field in hopes of earning a few extra dollars. Should this be permitted, I am afraid that what should be a well organized program would develop into chaos. As some of the chemicals now used are dangerous, this work cannot be trusted to just anyone no matter how many flies or farm crops they have sprayed.

[1] Minnesota Department of Conservation, St. Paul, Minnesota.

FURTHER STUDIES ON THE USE OF DALAPON FOR THE CONTROL OF CATTAIL[1]

B. H. Grigsby,[2] C. A. Reimer[3] and W. A. Cutler[4]

In 1954 dalapon (2, 2-dichloropionic acid) was applied as the sodium salt at various rates to cattail growing in drainage ditches. The results (1) from these applications indicated that a rapid top kill and seasonal control could be obtained. The data also indicated that when either 2,4,5-T or silvex (2 [2,4,5-trichlorophenoxy] propionic acid) were added, a more rapid destruction of top-growth occurred. These were applied as the propylene glycol butyl ether esters. However, evaluation of the treatments with respect to cattail eradication was not possible prior to the first report because of the limited time between spray application and the end of the 1954 growing season.

This report is based on continued observation of the original spray plots, retreatment of portions of these plots, and on the application of other rates of dalapon with the addition of 2,4,5-T as well as emulsified fuel oil. Boom application of relatively low volumes of spray solution, also were included.

During the first week of June, 1955, observations were made on the plots sprayed in 1954. All plots were rated with respect to the amount of cattail re-growth. These data, Table 1, show that estimates of effectiveness made approximately three months after spraying were reasonably accurate. Ratings made 12 months after spraying took into account any re-growth made by treated plants but were not affected by invasion of seedlings or buds from roots of untreated plants.

The lowest rate of application of dalapon, 6.8 lbs. per 100 gals., gave an appreciable control of cattail but enough plants survived to provide for a rapid re-infestation of the sprayed area. The addition of either silvex or 2,4,5-T to 6.8 lbs. dalapon did not reduce the amount of re-growth.

Table 1. Materials, rates and ratings of cattail plots sprayed in June, 1954.

Materials and rates in lbs. acid equivalent/100 gal.							Locations and ratings in fall 1954 and spring 1955.					
Dalapon	Silvex	2,4,5-T	Wheeler Fa.	Wheeler Spr.	Capac F	Capac S	Fairgrove F	Fairgrove S	South Haven F	South Haven S	Averages F	Averages S
6.8	0	0	8	9	5	9	4	6	8	9	6.2	8.2
6.8	1	0	6	8	8	9	8	9	9	7	7.8	8.2
6.8	0	1	8	9	8	10	8	9	6	5	7.5	8.2
13.6	0	0	8	10	10	10	4	8	8	8	7.5	9.0
13.6	1	0	7	7	10	9	10	9	9	9	9.0	8.5
13.6	0	1	8	7	10	10	10	10	10	8	9.5	8.8
20.4	0	0	8	9	10	10	9	9	—	—	9.0	9.3
20.4	1	0	6	8	10	9	9	8	—	—	8.3	8.3
20.4	0	1	9	9	10	9	10	10	—	—	9.7	9.3

Rating scale: 1—no visible effects. 10—no visible re-growth.

Rates of 13.6 lbs. and 20.4 lbs. were more effective than 6.8 lbs. but there were no differences between the two higher rates. These data do not reveal any increase in control due to the inclusion of 2,4,5-T or silvex.

It should be noted, however, that the addition of the growth regulators brought about a more rapid breaking up of sprayed foliage and thus would facilitate the removal of debris from the ditch and would aid in restoring the calculated flow capacity of the channel.

In 1955, one-half of each plot sprayed in 1954 was re-treated with approximately the same amount of herbicidal solution, and an equivalent area of cattail which had not been previously sprayed was included in

the new plots. When these plots were examined, in August, 1955, it was observed that the pattern of top kill was similar to that obtained in 1954. The ratings showed that two applications spaced one year apart brought about a top kill and apparent complete eradication of the cattail stand at all rates of application. Thus, it is apparent that while the 6.8 lb. rate of dalapon did not kill all cattail in a single season, two treatments at this rate were as satisfactory as a single spraying with 13.6 or 20.4 lbs.

In addition to the effects on cattails, some effects upon other vegetation were noted. Plots sprayed in 1954 were invaded by a heavy growth of water plantain (*Alisma plantago-aquatica*). A repeat application of dalapon alone did not appreciably affect this plant. However, when silvex was added to the spray solution seedstalk formation by water plantain was prevented. This effect is of minor importance but would contribute to a more rapid flow of water in the ditch.

Further sprayings were made in an attempt to determine the degree of top kill that could be obtained by lower rates of dalapon and the inclusion of 2,4,5-T and a wetting agent. In these tests a non-ionic wetting agent (Dynawet) was used to emulsify a quantity of fuel oil equivalent to the amount of oil present in the stock 2,4,5-T preparation. The materials used and ratings obtained are shown in Table 2. Sprays were applied June 23 and ratings made August 1, 1955.

The data show that the oil and wetting agent did not increase the effectiveness of small amounts of dalapon. A slight increase in activity due to the inclusion of 2,4,5-T was observed.

Applications of dalapon at a rate of 15.2 pounds per acre were made with a boom applicator. The boom was one of the single nozzle broadcast types which applied the solution at a rate of 40 gallons per acre with a spraying pressure of 50 psi.

Results obtained with this type of application were similar to those obtained with the gun applicator used in the previous trials. The cattails became brown in about two weeks and no further growth occurred prior to the time of the first killing frost in September. Boom application would permit a considerable saving in time and material required for the control of large areas of cattail.

The data secured from applications of dalapon in 1954 and 1955 indicate that eradication of cattail with this chemical is possible. Six to 14 pounds of dalapon in 100 gallons of water applied at a rate of 50 to 200 gallons per acre have given excellent control. The lower amounts may require additional applications; however, the 14 pound rate generally was effective when a single spraying was made.

The addition of growth regulators, such as 2,4,5-T and silvex, may lead to a more rapid removal of cattail tops and thus justify the additional cost due to the inclusion of these compounds. Where brush is present in parts of a ditch, spraying with dalapon and 2,4,5-T is a desirable procedure.

Table 2. Effects of Dalapon, 2,4,5-T and a wetting agent on cattail sprayed in June, 1955.

Materials per 100 gals. water			
Dalapon, lbs. acid equivalent	2,4,5-T, lbs. acid equivalent	Wetting agent and oil, qts.	Ratings, Aug. 1955
1.9	0	1	4.0
3.8	0	1	7.0
7.6	0	1	8.5
1.9	1	0	8.0
3.8	1	0	9.0
7.6	1	0	10.0
0	1	0	1.0
0	2	0	1.5
7.6	0	0	9.0

Literature cited.

(1) Grigsby, B. H., C. A. Reimer and W. A. Cutler: Observations on the Control of Cattail, *Typha* spp., by chemical sprays. Mich. Agric. Exp. Sta. Quar. Bul. 37: 400-406. 1955.

1 Journal Articles No. 1854, Mich. Agric. Exp. Station.
2 Professor of Botany, Michigan State University.
3 Horticulturist, Agr. Chem. Res., The Dow Chemical Company.
4 Assistant Professor of Agr. Eng., Michigan State University.

CHEMICAL WEED CONTROL ON OHIO'S HIGHWAYS

Wilbur J. Garmhausen[1]

The purpose of this paper is to show the value of a herbicide program in turf management. I will discuss some of the problems of this type of control and point out its practical and economical importance for highway purposes.

Our program had its inception early in 1945 when we began experiments in using herbicides to eradicate poison ivy. The following year we included areas that could not be mowed by power equipment. In 1947 a total of 850.17 miles were sprayed at a cost of $14.62 per mile. Our conclusions at the close of this short period were; time loss and suffering due to ivy poisoning was greatly reduced, the vegetation was more effectively controlled, and the right of way was cleaner and economically maintained.

In 1951 we decided to spray all the roadsides in an entire county. The 264.55 miles were sprayed at a cost of $18.37 per mile. Our program continued to expand because of results obtained. In 1955, 2,4,-D, and 2,4,5-T, were applied to 9,294 miles of roadsides of the 15,996 miles of rural state highways in 64 of Ohio's 88 counties at a cost of $191,314.45.

The average cost of spray treatment per mile per season has risen from $16.39 (1953) to $20.58 (1955). This is due chiefly to more intensified effort to cover the right of way completely with spray, and to more wide spread use of the multiple type spray program. Of greater interest, however, is the lowering of mowing costs. In 1953 it cost $91.78 per season to mow each mile (both sides) that was sprayed and $92.75 per mile to mow roads not sprayed. In 1954 it cost $82.61 per mile to mow roads sprayed against $117.89 per mile not sprayed. In 1955 it was $69.33 per mile to mow roads that were sprayed, and an estimated $119.00 per mile not sprayed. However, the true costs per mile should be obtained by combining the spray and mowing costs. In 1953 the combined cost was $108.17 per mile; in 1954, $102.02 per mile; and in 1955, $89.91 per mile.

Increased wages in the past three years makes the lowering of mowing costs even greater. There are other operational costs proportionately lower with reduced mowing. One Division which sprayed 53% of their rural mileage (1955) estimated a saving of $3,000 in the maintenance and repair of their mowing equipment, plus the fact that more labor time can be spent otherwise. Our program established the facts that our roadsides need less mowing, that hand mowing is almost entirely eliminated and that the roadsides present a neater appearance.

With so wide a general acceptance of the spray operation, as an aid to roadside maintenance, we must guard against over enthusiasm. This herbicidal material remains a potent and deadly force when misdirected. Applications to valuable plants on the right of way can arouse public criticism both as to destruction and operation.

Large damage claims can result if the spray reaches susceptible plants in fields, gardens or home plantings.

XUM

In the past year Ohio had a total of 37 damage claims. 19 occurred on the 3,752 miles of contract spraying. Of these seven were for cattle, five for trees and shrubs, five for vegetables and two for crop damage. Eighteen occurred on 6,542 miles of force account spraying. Of these three were for cattle, five for trees and shrubs, six for vegetables and four for crop damage. After contacting the owners, two of the field crop and two of the vegetable claims were dropped. By quick action and cooperation with the State Veterinarian the cattle were diagnosed as having died from other causes not due to spray. We have yet to be found guilty of killing cattle. These findings will be made available for the personnel doing the spraying and for all local veterinarians.

Will such a program meet the needs of other State Highway Departments? This will depend to what extent they develop it and their knowledge of some of the problems. Qualified personnel will have to be trained, as the success of the operation depends greatly upon how well informed the men are who are actually doing the spraying.

When a spray program is adopted consideration will have to be given to contract vs force account spraying, which is done with highway personnel. Things in favor of contract spraying are, lower costs, greater saving on equipment, speed of application, claims for damage handled by contractor. For force account spraying, closer control, application to all needed parts of right of way, heavier application where needed, criticism and complaints from organizations and individuals will have to be answered and claims for damages will have to be met.

Based on the success of herbicide control on Ohio's roadsides I can make the following recommendations to you: (1) That a three year program of three sprays per season be used. (2) That the first spray be applied early in the season and the mixture contain a minimum of three pounds acid equivalent of a polypropylene glycol butyl ether ester or a butoxyethanol ester of 2,4-D per 100 gallon of water at a minimum rate of 100 gallon per mile (2½ to 3 A.) (3) That the second application be performed by July first and contain two pounds of 2,4-D and one pound of 2,4,5-T. (4) That the third spray be applied before September first and contain three pounds 2,4-D. (5) That the equipment be prequalified 1,000 gallon sprayers. (6) That after a three year period only one application per year be made. (7) That trained crews and accurate amounts of material be used and that wind, atmospheric conditions and susceptible vegetation be considered. (8) That prior to spraying the areas should be investigated and that slopes subject to erosion should not be sprayed. Likewise, desirable vegetation should be designated not to be sprayed. (9) That spraying and mowing operations be coordinated and a fertilizing program be included.

(10) That when cattle claims arise, you work very closely with your University and with the Department of Agriculture, especially the Veterinary Division. (11) That all damage claims should be investigated. (12) That no opportunity be overlooked to promote good public relations. Publicity should stress safety, economy, and efficiency.

[1] Chief Landscape Architect, Ohio Department of Highways, Columbus 15, Ohio.

PERFORMANCE OF ERBON FOR EXTENDED VEGETATION CONTROL IN THE NORTH CENTRAL STATES

R. L. Warden and J. H. Davidson[1]

Erbon is the proposed common name for the new herbicide 2(2,4,5-trichlorophenoxy) ethyl 2,2-dichloropropionate. This chemical and its herbicidal properties has been reviewed in a technical bulletin (1) published a year ago. During 1955, the emulsifiable formulation* has been used in more extensive experimental and commercial applications. The performance of this formulation in the North Central area will be reviewed in this paper.

Factors Affecting Performance

Seasonal control of average grass and broadleaf vegetation requires 120 to 160 pounds of erbon per acre. In areas where the predominant vegetation to be controlled is susceptible to erbon and rainfall is not excessive, 100 pounds may be sufficient.

Experiments conducted with erbon indicate that if maximum effectiveness is to be obtained it should be applied in late spring or early summer when most of the vegetation is growing vigorously. While erbon has some systemic action applications made at this time will generally be followed by a small amount of rainfall to carry the chemical into the soil yet not enough to cause excessive leaching Applications made very early in the spring, may be subjected to heavy spring rains, and be leached excessively. This loss of chemical can permit seed germination later in the growing season. Erbon applications made on vegetation after considerable growth has occurred may give quick top kill but complete response on certain perennial weeds is slow.

A single annual application of erbon properly timed should be expected to give commercial control of vegetation during the growing season in most areas of moderate rainfall. Experience gained during the past two seasons indicates that certain weeds are difficult to control. Some of the more common tolerant weeds are: Canada thistle, narrow and wide leaved plantain, bracken fern, common milkweed and dock. Where such weeds are known to be a serious problem some regrowth may be expected late in the season and the maximum rate of erbon should be applied. In areas where the more tolerant weeds are not a serious problem, reduced annual dosages following the first season may be sufficient to maintain residual control of seedlings. In many situations a small amount of regrowth on treated areas late in the season may prove desirable to reduce wind or water erosion during the winter.

A sufficient volume of water should be used with erbon to insure complete wetting of the vegetation if contact action is desired. This often requires 100 to 300 gallons of spray per acre. Lower volumes of spray are satisfactory for preventing weed seedling emergence from bare ground.

Hazards to Adjacent Vegetation

Excessive spray drift from applications of erbon can cause damage to nearby vegetation but little injury has occurred in the field where reasonable care has been exercised during spray application.

Soil applications in the vicinity of desired vegetation indicate that there is a fairly wide margin of safety if only a small percentage of the root zone area of the desired plant is treated. Applications of erbon made under guide rails and fences or along dirt roads in the vicinity of desired turf shrubs or trees have not caused apparent damage. Spraying the entire area over the zone occupied by roots of trees or shrubs should be avoided as serious injury from such applications has occurred. Lateral movement of erbon in the soil at lethal concentrations has been minor. Under most conditions such movement has not been more than six to eight inches. In some instances where erbon has been applied on hard packed soil lateral movement due to washing has been greater.

Suggested Uses

Tests with erbon for vegetation control in areas where moderate rainfall occurs indicate that more extensive use of the material is justified. Some of the uses where erbon was successfully employed this past season are as follows:

1. To eliminate hand mowing in such areas as those

around guide rails, guide posts, sign posts and bridges.

2. To control unwanted vegetation in such areas as tank farms, lumber yards, railroad yards, pulp piling yards, property fences around industrial plants, transformer stations, parking lots, athletic tracks, driving range tees, and sand traps.

[1] The Dow Chemical Company, Midland, Michigan.
[*] Erbon is supplied in an emulsifiable formulation under the trade name Baron. This formulation contains four pounds of technical erbon per gallon.
(1) Erbon technical bulletin No. 1, January, 1955, The Dow Chemical Company.

EFFECT OF CUTTING AND HERBICIDAL TREATMENT ON CONTROL OF OAK SPROUTS[1]

Harry M. Elwell and Maurice B. Cox[2]

A major problem in the removal of oak and associated hardwood brush is to prevent the regrowth from reinfesting the area. Considerable acreages of brush have been cleared in Oklahoma, either by hand cutting, powered saws, or bulldozing. Where the sprouts are not mowed annually following such methods of removal a denser stand usually develops than originally occupied the land. Annual spring mowings of oak sprouts keep them sufficiently suppressed to permit the native grasses to provide a good land cover. However, many oak sprouts have remained on land even after fourteen years of consecutive mowings.

In order to determine the effect various dates of cutting might have on suppressing oak resprouts, eleven plots, each 60 feet wide and 460 feet long, were established. Starting about the middle of March in 1948, all the brush on one of the plots was cut with a power saw, piled, and burned. An additional plot was treated in the same manner about the middle of each month thereafter, from April through October. There were three untreated plots. In the following years, 1949, 1950, and 1951, two-thirds of each plot for the particular month was cut to remove the regrowth.

The oak species on this area were blackjack (*Quercus marilandica* Muench), white (*Quercus alba* L), post (*Quercus stellata* Wang), and chinquapin (*Quercus prinoides*, Wild.). All of these woody plants sprout profusely when cut or injured by fire. This is particularly true of trees 6 inches or less in trunk diameter.

Data presented in Table 1 show that none of the cuttings made during the different months reduced the sprout growth.

Since time of cutting had not produced a satisfactory control of regrowth on the original study, spraying tests were initiated in June, 1952, across the area. A section 100 feet wide and across all eleven plots was treated with a wetting foliage spray containing 3 pounds of acid equivalent of a herbicide in 100 gallons of water. The herbicide used was a butoxy ethanol ester containing two-thirds 2,4-D and one-third 2,4,5-T. This area was retreated with the same spray in 1953 and an initial spray was applied to another 100-foot strip across all of the plots. A retreatment was made on this latter area in 1954.

In November, 1955, counts were made on the effect of the herbicide on the regrowth and on the uncleared areas. An average of the data for both 100-foot strips is given in Table 2. There was a very low apparent kill of the one- and two-year old sprouts for all of the months mowing was done, except for those that developed following the October mechanical treatment. This is shown by data in the third column of the table. The regrowth that had been permitted to grow for three or four years after the original mechanical removal had a higher apparent kill. This was particularly true for areas cleared originally during the months of June through October.

Other preliminary studies using a low volatile ester of 2,4,5-T to control one- and two-year old sprouts indicate that it is slightly more effective than the 2,4-D—2,4,5-T mixture described above.

Results from a large number of foliage applications made with both ground and aerial sprayers show that the penoxy type selective herbicides are more toxic to undisturbed hardwood brush than to regrowth under three years of age.

Table 1. Oak and Associated Hardwood Brush per Acre on Areas prior to Mechanical Clearing and Number of Plant Stems Occurring as Regrowth following Annual Cutting. Guthrie, Oklahoma.

Treatment Period	When Cleared 1948	Number of Plants After Annual Cuttings 1949	1950	1951	Average for 1949-1951
March	14,984	28,386	26,535	25,337	26,753
April	14,984	28,532	26,898	25,446	26,959
May	12,398	45,883	55,720	37,571	46,391
June	12,398	24,030	51,764	58,080	44,625
July	16,606	34,775	49,295	42,544	42,205
August	16,606	42,108	54,123	38,042	44,758
September	17,954	63,162	60,766	59,060	60,996
October	17,954	28,677	57,753	65,955	47,795

Table 2. Effect of a Butoxy Ethanol Ester Herbicide, Two-Thirds 2,4-D and One-Third 2,4,5-T, on Control of Oak Sprouts on Areas Mechanically Cleared and Mowed at Monthly Intervals. Guthrie, Oklahoma.[*]

Months	Percent of All Plants Apparently Dead on Areas Cleared and Sprouts Let Grow for 3 Years (1949-1951)	Cleared and Sprouts Cut Annually for 3 Years (1949-1951)	Difference
March	45.1	11.8	33.3
April	56.4	19.8	36.6
May	43.3	26.7	16.6
June	62.0	37.1	24.9
July	60.3	38.2	22.1
August	74.7	28.3	46.4
September	82.4	54.6	27.8
October	91.4	85.8	5.6
Average	64.5	37.8	26.7
Areas not cleared	72.4		

[*] Two yearly herbicidal treatments, each at 3 pounds per acre, were made between 1952 and 1954.

[1] Contributions from Agricultural Research Service, U. S. Department of Agriculture, and Oklahoma Agricultural Experiment Station.
[2] Respectively, Research Agronomist, Field Crops Branch, and Agricultural Engineer, Soil and Water Conservation Branch, Agricultural Research Service, Red Plains Conservation Experiment Station, Guthrie, Oklahoma.

DATA ON THE USE OF THE HANDGUN FOR BASAL APPLICATIONS FOR BRUSH CONTROL

R. E. Larson[1]

The use of a power sprayer with a handgun attachment as a method of applying basal treatments for brush control is being used more and more by power companies for right-of-way maintenance. It also provides a more mechanized method of application for brush control in large pasture areas than does the small compressed air hand sprayer. There has been very little in the recommendations concerning the proper rates to use with such power equipment or for the manner in which it should be used. This study was undertaken to determine the

XUM

equipment factors to be considered by those desiring to use this method of brush control.

The study was set up to find the effect of such factors as type of handgun, orifice size, stem size, bark condition and operators. To provide for uniform trials, selected posts were cut and set in the ground in an open area. Four hundred such posts were placed in a ¼-acre area to represent a natural stand of 1600 stems per acre. The stems were group by diameter size into 3 classes: 1" to 2", 2" to 3", 3" and over. They were also grouped by species to include equal numbers of hickory *(Carya spp.)* and oak *(Quercus spp.)*. This species classification was used to provide characteristically smooth and rough bark conditions. The stems were located at random within size and species groups to simulate the spacing of a natural stand.

The method of shutoff was the primary basis for determining the handguns to be used in this study. Location of the shutoff mechanism was a secondary consideration. There were two handguns equipped with a trigger type shutoff; one with short barrel and one with a long barrel. Also included were two spray guns with a turn type shutoff; one with the shutoff handle at the rear and one with the shutoff under the barrel.

Orifice sizes included were .0781" (#5), .0937" (#6), .1250" (#8), and .1565" (#10), Three operators were used in the study. Water was used as a spray material and the equipment operated at a pressure of 30 psi.

Table 1. Gallons Per 1000 Stems Applied by 4 Handguns and 4 Orifice Sizes.

Handgun	Orifice Sizes* #5	#6	#8	#10	Av. for Handgun	Av. for Type of Shutoff
Trigger type #1	31.9	35.6	44.3	52.4	41.0	
Trigger type #2	23.4	28.0	32.1	37.2	30.2	35.6
Turn shutoff #3	40.8	43.1	61.6	74.5	55.0	
Turn shutoff #4	25.4	34.0	43.6	53.9	39.2	47.1
Av. for orifice	30.4	35.2	45.4	54.5	41.4	

* All applications by one operator, three size classes, two species.

The results (Table 1) giving the average output based on the type of shutoff would seem to show a difference in favor of the trigger type. A closer analysis of the results for individual handguns reveals the difference to be almost entirely between #2 and #3 which gave results of 30.2 and 55.0 gallons per 1000 stems, respectively, and include one of each type of shutoff. The other handguns, #1 and #4, have almost identical outputs of 41.0 and 39.2 per 1000 stems, respectively, and here again there is one of each type of shutoff. This would indicate there is a difference due to the design and use of the individual handgun rather than to the general method of shutoff.

The output results (Table 1) show the orifice effect to be proportional to its size ranging from 30.4 gal./1000 stems for the #5 (.0781") orifice to 54.5 gal./1000 stems for the #10 (.1565") orifice.

The effect of the bark condition or type is indicated by the results as given in Table 2 which support the expected trend in that the rough bark requires more

Table 2. Amount of Spray Material Used as Affected by Type of Bark.

Bark Condition	Quantity of Spray Applied (cc./dia. inch)* Orifice size #5	#6	#8	#10	Av.
Rough (Oak)	48.1	63.2	77.5	89.9	69.7
Smooth (Hickory)	41.6	55.3	67.5	80.7	61.3
Percent Difference**	15.6	14.3	14.8	11.4	13.7

* One operator, three size classes.

** Increase in the amount applied to oak as compared to the amount applied to the hickory.

solution per diameter inch than does the smooth bark before the runoff point is reached. The oak or rough stems require an average 13.7% more than the hickory or smooth stems. The total average amounts applied to the rough and smooth barks by the 4 orifice sizes are 69.7 and 61.3 cc/di. in., respectively.

The size of the stem has a direct relationship to the amount of spray necessary for 1000 stems. The required amount of spray ranges from 27.5 gals./1000 stems for the 1½" class with a #5 orifice to 60.9 gals./1000 stems for the 3½" class with a #10 orifice. The overall average for the three classes using four orifice sizes is 41.4 gals./1000 stems. The results in terms of cc/dia. in. are also shown in Table 3 and indicate the amount applied per dia. in. varies inversely with the size of the stems.

Table 3. Amount of Spray Used as Determined by the Size of Stem.

Stem Size	Quantity of Spray Applied* gal./1000 stems Orifice size #5	#6	#8	#10	Av.	cc./dia. in. Orifice size #5	#6	#8	#10	Av.
1½"	27.5	30.6	39.9	49.0	36.8	63.7	80.0	99.0	122.5	91.3
2½"	28.0	33.1	43.8	53.5	39.6	42.4	56.9	67.1	84.7	62.8
3½"	35.6	41.9	52.5	60.9	47.7	37.2	51.8	63.9	70.5	55.8
Av.	30.4	35.2	45.4	54.5	41.4	47.8	62.9	76.7	92.6	70.0

* One operator using 4 handguns.

A large part of this variation is apparently due to the greater proportionate amount that misses the stem and falls to the ground when spraying the smaller stems.

The operator is shown to be a factor which provides one of the greatest sources of variation in the amount of material applied by this method of treating. This is in evidence as shown in Table 4 in that operator C used approximately 28% more spray material than did operator M. The amount applied by operator G was between the amounts applied by the other two. After the operators became accustomed to the job, they were surprisingly consistent in the characteristic amounts applied by each.

Table 4. Amount of Spray Used as Affected by the Operator.

Operator	Amount of Spray Used (gal./1000 stems)* Orifice size #5	#6	#8	Av.
G	32.4	35.9	45.0	37.8
C	36.5	40.4	55.0	44.0
M	21.5	38.0	43.0	34.2
Av.	30.1	38.1	47.7	38.6

* Using one handgun on all sizes and species.

A summary of the result of these studies indicates that in using this method of application for brush control it is advisable to make an equipment calibration before mixing the herbicide for the application. After making such a calibration, reasonable estimates of changes in output can be made for changes in orifice size, stem size, or species as is represented by a change in the type of bark. On the other hand, a change in operator or handgun will necessitate a new calibration as the effect of these two factors is not predictable.

1 Agricultural Engineering Research Branch A.R.S., USDA, Columbia, Missouri.

"ARE WE GETING THE JOB DONE IN WEED CONTROL?"

C. J. Gilbert[1]

It is a profitable thing to stop in the road and look back, after one has climbed for awhile, to see in better perspective the distance and height one has traveled.

Every person in this room has enjoyed, has been benefited, has profited, (and at this very moment is so doing) from an investment, or investments, of someone who has gone before, or is now living as his contemporary. Simple things that are precious to all of us, and things that we now consider as everyday necessities, are ours because someone, or many people, worked, gave of their substance, time, treasure, labor and influence to bring into being. Homes, rural improvements, city development, churches, schools, paved streets, highways, telephones, electricity, radios and other things that we

prize highly are ours because of the investments of others. Fraternal bodies, lodges and clubs, have had leaders who gave that those who come after should have the benefit. We all belong to some church, or should. There is not a church edifice in the realm of your knowledge or mine, be it old or new and modern, that does not stand in its place of service to human kind except because some 'investor' labored and gave. Not long ago, I saw a new, fine looking church building and I think I could have named some of those 'investors,' who also could have been listed among the pioneers who built the first building on that site. In another town, I saw a beautiful and practical community center; in another, I saw a lodge hall; in another I saw an endowed school; elsewhere I see hospitals. The list could go on naming good things resulting from investments of those we know or knew. Most of us belong to organizations that all of whatever is good in their present state we owe to those ahead who built or started to build for us. We are debtors to the investments of others.

In 1944, on June 3, in the early dawn of that fateful day, two platoons of the 142nd infantry regiment were in position against the so-called impregnable "Velletri Line." They had infiltrated through enemy terrain, bristling with every conceivable weapon and warning system then known to military men. They had already done what was said couldn't be done. That day, those men, positioned in place of peril, made it possible to take the "Velletri Line" which the military world said could not be taken. Very few came back from their great task of investment.

So this speaker belongs to a group, and which membership he would willingly give his life to cancel, to bring back another life. Any Gold Star father would do the same. Such is not given to us to do, however, and the only privilege that is ours is to be worthy of so great an investment in a country that has given so much and for which so much has been given.

Perhaps on that very June day, the Rosenbergs were passing secret information which resulted in killing others who also made great investments. And during those war years, and since, others in the traitor class have been doing the same, or other things, to destroy this nation for which investments of so great magnitude were made.

I think you can understand, therefore, the utter and profound contempt I hold for those who do that sort of thing; for those who defend them and cover up for them. I think you can also understand my disdain for those who prevent, or try to prevent, the rooting out of these vermin; who criticize, castigate, vilify, decry and berate men, organizations and committees who are rendering a service they themselves haven't the guts to perform. Whether they be of my political party, or yours, or none, I despise their thinking.

The weed control programs of your state and mine have been built by the investments of many. The people of our states have invested money for paid leadership; for research, for channels of information; for printed bulletins; for regulatory employees; posters and other media. Counties and districts have added to their financial investments. To some people, this expenditure of public money is the largest and most important. I wonder if it is. I am thinking of other investments that cannot be tabulated on the adding machine. The years of unpaid and unthanked effort of individuals in their effort to awake public consciousness and opinion, and to get an effective weed control statute on the books. The efforts of individual members and of the organizations of the Crop Improvement Associations, better farming groups, and agricultural associations, to bring into being a functioning weed control program. The many years that men with otherwise full schedules have given to weed control and added it to their duties. The years of service of county weed board members, unpaid, and with no compensation for expenses. The only reward those men have received, or will receive, is a final awakening on the part of land owners, land operators, business men of our towns, legislators and public leaders, that land growing noxious and costly weeds does not produce much for people to live by.

We have seen some county extension agents, already busy, almost beyond capacity, but recognizing fully that land made unproductive because of weeds can be a most serious illness of agriculture, accept the responsibility and challenge of the weed menace, and they made an investment in carrying on a program of education and control organization within their counties.

We have seen some county commissioners who have recognized that weeds cost more than county governments, in some cases several times, and have invested their leadership in promoting and cooperating with county weed control programs. Newspapers have often invested their only commodity, white space and influence, to encourage weed control activity. Radio and television stations have offered and given of their time and talent to promote weed control practices and programs. Bankers have made contributions to local weed control programs among 4-H Clubs. Four-H Club leaders, school teachers and county superintendents have helped members and pupils prepare weed scrap books of great beauty and teaching assistance. Legislators of vision and integrity have supported and defended our approach to reducing the tremendous losses to our states because of weed growth. These are investments that adding machines cannot give an answer for, or have a total figure to give. There have been others.

As you and I assemble here this morning, we are the recipients and heirs of great investments of which public money may be, by far, the smallest item. The question that we have to answer in one way or another is—What are we going to do with these investments in order to make them pay out? We can abuse them, misuse them, ignore them, or permit them to be wasted. We can also preserve them and multiply their value.

Then there are others who have made great investments in your weed control programs. These individuals, farm operators, owners, tenants, public land officials and supervisors, and farm managers. They do not get their names in the papers very often; they rarely get public praise; they are not given even public recognition and certainly get little glory; but without them we might just as well close shop and admit that these investments have been injured. These men are just good farmers. They, year after year, take care of the weeds on their own farms. But, while they do this good job, others in the neighborhood "Let 'em grow," "Let 'em blow," and "Let 'em go" to the good farmers' clean land. We can no longer permit these investments of the good farmers and others to be destroyed and dissipated.

If we are to measure up to the expectations of those who have made all of the investments I have named; to measure up to our responsibilities as leaders, as conservers and guardians of the welfare of our counties, our communities, we must go farther than many of us have gone. These men and their investments must be protected.

Not too long ago, this story was told to me by a man in one of our counties. He said that twenty-seven years before, his father, (recognized as one of the best farmers in his county, by the way) had found and started to eradicate a patch of leafy spurge that he had found and identified on the farm. The father had not lived long enough to get the job done and the son had inherited the farm and the spurge. The son had continued the job, using all the approved chemicals and methods then known, and five years ago he thought he had the job done. For five years no spurge plants returned or were seen, but a year ago he found some plants appearing again. Now **he** doesn't know if he is going to live long enough to get complete eradication. Noxious weed seeds lay in the ground a long time; our Canadian friends have found that spurge seed will stay in the ground for 30 years, and still grow. He has been a good farmer; his father was a good farmer; he has been a good neighbor; a good weed fighter; and now, after all that effort, time,

XUM

labor, and cost, if some careless, lazy "don't care type" of farmer near him should reseed his farm with this or some other noxious weed, what will become of his investment of the years? Control, elimination and eradication of these criminals of the plant kingdom is not a short, easy task for those who have them. For those who do not have them, prevention is their great opportunity. If we ignore the investment of those who have clean land, or are trying to keep it clean, we are failing in our task, and we are not getting the job done.

This is the Christmas Season. All of us give greater consideration and thinking to the life and teachings of The Galilean at this season than at many other times. When He attempted to describe a man who was mean, comtemptible, underhanded, a scoundrel and worthy of scorn, He described him as an enemy and said, "While men slept his enemy sowed tares among the wheat." What about the people in your neighborhood, your county or state, who, by neglect, carelesssness, obstinacy and wilfulness, insist in keeping little 'nurseries', patches of undestroyed noxious weeds, and seed down clean land with weed seeds so that they may become a burden to the owner, and deprive him of his livelihood. Is enemy too strong a word? Certainly he is not a friend. If you are going to get the job done in weed control, it is time that you and others, that we, band ourselves together in community and neighborhood groups to see that such unfriendly practices cease. Regulatory actions and law enforcement are distasteful, but investments of good farmers, good leaders, good legislators must be protected and you are a part of that protection. Are we getting the job done? Where organized people insist on action under the statute, it will happen, or they change the enforcing officials. The encouraging thing in this picture is, that when people work together in such neighborhood and community organization groups, relatively few actual enforcements are found necessary, and the job is done better.

But there have been some regulatory cases and there will be more. The excuses that men give cannot be accepted for always. For those who cannot properly direct their own conduct and actions, something else must be added. There are some who just don't care. Like the Missouri mule, of which you have all heard, that went around running into fences, butting its head into the side of the barn, climbing over the feed bunks and machinery in the yard. His owner insisted he wasn't blind, but 'just didn't give a damn.' There are some of those people too, and their attacks on great investments must be met with something besides averted eyes.

Then there is the man who blames his weeds on the previous farmer; it isn't his fault and he won't do anything. Another hasn't time. Another is leaving the farm the first of March; (he'll probably be leaving the next one the first of the next March, too.) The landlord is a scoundrel; he won't pay his share of weed control expenses. It won't work anyway. The birds need the weed seed; the county or township road has weeds; why don't they clean them up? And the county commissioners or township surpervisors say the farmers have weeds. What good will it do for them to kill weeds? Pete Anderson, three miles away, has some noxious weeds; my mother-in-law owns the farm and she doesn't believe in weed control. And the good one, "I don't need advice from anyone—that includes **you.**" Wouldn't a glossary or compilation of excuses for not being a good weed fighter be a best seller? It has occured to me to make up a sheet of them and when our men found a farm where noxious weeds were uncontrolled, have them send the sheet and put on it: "You have failed to destroy noxious weeds as required by law. Please check your excuse and return." The time when action has taken the place of excuses, then we are getting the job done. When we have determined that the investments, substantial in money, large in effort of our predecessors, huge in the labor of good farmers, will not be lost, we are on the way to getting the job done in weed control.

When we, as weed control workers, state, county, township officials, neighbors, citizens, believe in the creed that crops and weeds cannot use the same land, the same soil elements and the same moisture, at the same time, and in the same place, and still have the crops produce as we want them to; when all of us have inspired the laggards, helped the cooperative ones, informed those who do not know, and persuaded the stubborn, all of these investments will have paid off dividends many fold. They are in our hands. What happens to them is our decision to make. When you can say they are safe, guarded, and protected, you and I can answer the question propounded in the subject of this talk.

"While men slept, an enemy sowed tares among the wheat."

1 South Dakota State Weed Board, College Station, South Dakota.

HOW WE CONTROL WEEDS ON THE FARM

A panel composed of three farmers, Howard Wahlgren, Elk City, Nebraska; Ray Beerman, Dakota City, Nebraska; and W. L. Reichelt, Dunlap, Iowa, discussed the essentials of a good weed control program as applied to farm conditions. Lyle Derscheid, South Dakota State College, served as research personnel and John Furrer as moderator.

The panel was conducted on a question and answer basis with Dr. Derscheid substantiating or explaining some of the results and practices experienced by the panel members. The following is a brief synopsis of each farmer's presentation.

W. L. Reichelt, Dunlap, Iowa. By profession, Dr. Reichelt is a dentist. Farming is a hobby. Dr. Reichelt used to get his exercise on the golf course but now it's on his farm. He acquired the land through inheritance and purchase in 1948. The land was producing 48 to 50 bushels of corn per acre; however, during the last couple of years, yields have almost doubled through the use of a corn, corn, oats, alfalfa rotation, commercial fertilizers, and weed control practices.

Corn is Dr. Reichelt's principal crop. Weeds which have given him the most trouble are buttonweeds, sunflowers, and cockleburs. After the corn is laid by, Dr. Reichelt, Mrs. Reichelt, their son, and the operator go through the corn with hoes and knapsack sprayers, hoeing and spraying 2,4-D on weeds which escaped cultivation. Grassy weeds and single plants of broadleafed weeds are hoed; heavier infestations are sprayed.

The first year, an oats crop was saved from weeds by timely spraying with 2,4-D. No apparent damage was evident in the oats. Legumes are now included in the oats acreage which eliminates spraying as a weed control measure. Good cultural practices and improved soil fertility encourage the oats and legumes to a degree that weeds are no longer a major problem in oats production.

An important phase of Dr. Reichelt's weed control program is the attention given to fence rows, turn rows, and waterways. These areas are seeded to perennial grasses, and then sprayed each year with 2,4-D applied with a knapsack sprayer. Dr. Reichelt shoulders the knapsack sprayer and walks the fence rows and field borders spraying the patches of weeds while Mrs. Reichelt uses the car to keep him supplied with spray material.

Ray Beerman, Dakota City, Nebraska. Mr. Beerman farms about 400 acres in the extreme northeast part of Nebraska. Approximately one-half the land goes into corn. Oats and alfalfa are other important crops. The corn and other crops are used for the feeding of hogs and cattle.

The weeds which have caused Ray Beerman the most

trouble are cocklebur, buttonweed, sunflower, and weedy grasses. He controls them by crop rotation, cultivation, and spraying. All his corn, 160 to 200 acres, has been sprayed each year for ten years with three-fourths of a pint of butyl ester per acre. Ray sprays each year because (1) there's always some weeds which escape the cultivator, (2) weed seed dormancy permits weeds to get a start even though they weren't present the previous year, and (3) feeding a lot of hogs and cattle makes it necessary to buy additional grain. Purchased feed grain often contains weed seeds which eventually get to the fields through droppings and manure applications.

The 2,4-D applications are made immediately after the second cultivation when the corn is about two feet tall. The results have been excellent. Sometimes kills are slow but the weeds are not present at picking time. If plant growth is slowed down because of cold weather or other conditions, 2,4-D doesn't always act as effectively. Spraying at the time of the second cultivation isn't exactly the best time to spray but it fits best into Mr. Beerman's program. Ray thinks that spraying after the third cultivation would be better. Not enough time elapses between the second and third cultivation and the corn is still brittle and leaning from 2,4-D effects. Some damage from 2,4-D does occur but the benefits more than offset the injury.

Oats are not sprayed because they serve as a nurse crop for alfalfa and clover.

Mr. Beerman maintains neat, clean fence rows by seeding to brome and by spraying twice a year with 2,4-D. The first spraying is done about June 1 and the second in August. Where corn is planted close to the fence, the second spraying is usually made at the time of the second cultivation.

Tanweed is a problem in much of Nebraska. 2,4-D retards the growth of tanweed enough to give the corn a chance. Small patches of field bindweed in fence rows were eliminated by using sodium chlorate. The twice-a-year sprayings keep down reinfestations. Wild morning glory was controlled by pulling in Ray's pre-farming days but now 2,4-D does the job.

Grassy weed control in corn presents one of the most difficult weed control problems. Present day chemicals are not too satisfactory. There is a place for a chemical which will give grassy weed control when applied at the time of or after the last cultivation. At present, the best control measure is to set the cultivator to best advantage.

Howard Wahlgren, Elk City, Nebraska. Mr. Wahlgren's principal farming interest is certified seed. In 1955 he had under the certification program 120 acres of grain sorghum, 40 acres of soybeans, and 40 acres of oats. Certified seed must be clean seed so Mr. Wahlgren has reason to be interested in weed control.

Smartweed, pigweed, and barnyard grass are among his most troublesome weeds in sorghum. The most satisfactory control measures are early seedbed preparation, the planting of clean seed, and timely cultivations. 2,4-D sprays are used during wet seasons when cultivation is sometimes difficult. Weeds which escape cultivation or spraying are pulled by hand. Roguing by hand is not as difficult as it may sound. It doesn't take too long to go through a field and pull out the weeds. There's a lot of personal satisfaction which comes with keeping fields clean. Smartweed seems to be one of the more persistent annual weeds; however, it can be whipped by careful cultivation and hand pulling.

Weed control practices for soybeans are essentially the same as for sorghum on Mr. Wahlgren's farm. Several early workings of the ground to encourage weed seed germination and ultimate destruction is especially important. Planting in rows, early cultivation, and hand weeding are musts for clean soybean fields.

Normally weeds don't bother in oats; however, the stand was thin one year which permitted weeds to get a good start. 2,4-D was used successfully without any noticeable injury to the oats.

Spraying doesn't play a very important part in Mr. Wahlgren's overall weed control program. He doesn't like to "lean" on spraying. Several fields have been cleaned up during the past 25 or 30 years to the point where weeds aren't a problem. Occasionally a sunflower or cocklebur does make its appearance but they are cared for by hoeing or pulling. Vigilance, planting clean seed, using clean equipment, timely cultivations and sprayings, hand pulling, and clean fence rows and roadsides are all important in the weed control program.

For fence row seedings Mr. Wahlgren prefers to remove the old fence and brush, level and prepare a good seedbed, and then seed to a good perennial grass such as brome prior to re-building the fence. Road rights-of-way should be well shaped and top dressed with fertilizer prior to seeding. Highway departments and others have been very cooperative with seeding programs.

Mr. Wahlgren has found that 2,4-D will eliminate the above-ground part of tanweed but it always seems to come back from the roots. Cultivation is an excellent control measure during dry seasons but isn't quite so effective when the soil is damp.

Milkweed was giving some trouble. One particular patch near the farmstead had been pulled for several years without any noticeable change in stand. 2,4-D ester was applied at three times the normal strength recommended for perennial weed control. Three applications of the triple strength mixture was applied at half hour intervals to the infestation. The milkweed was completely eliminated with this treatment.

When strange weeds such as yellow star thistle and giant foxtail make their appearance, first of all find out what they are and then make every effort to eliminate them. If we are alert at all times, weed control problems will be simplified.

THE FARMER'S CHEMICAL KIT FOR WEED CONTROL

E. P. Sylwester[1]

Any presentation which gives a bird's-eye view of the numerous chemicals at the disposal of the American famer for weed control should be preceded by at least a summarization of the cultural methods of weed control which are the foundation stones of our attack on weeds. Sound cultural practices of weed control at the disposal of every American farmer form the backbone of our fight against weeds. They are the foundation stones upon which the house of chemical weed control rests. Chemicals are, for the most part, most advantageously used in conjuction with, or as an adjunct to, good cultural weed control, never as a substitute for them. Even our best farmers, however, often find themselves at a disadvantage in their fight against weeds without chemicals. At the present time, our farmers are equipped with the best tools for cultural and chemical weed control that the world has ever seen. Coupled with the machinery is that typical all-American asset of ingenuity, of which we are justly proud. Coupled with good machinery and ingenuity, a farmer now has in addition approximately 25-30 proven chemicals to aid him in his never ending battle against weeds. As a result, the American farmer is in the most advantageous position to cut down the depredations caused by weeds, to do it more cheaply and more effectively, than has ever been the case heretofore. It is eleven years ago, in 1944, that this organization first met in this city. At that time, cultural weed control formed the backbone of our recommendations. At that time, Dr. Kephart from the United States Department of Agriculture gave us

XUM

just a misty glimpse of a wonderful new weed control chemical which was in the making. The entire talk which he delivered encompassed only approximately thirty minutes, and approximately ten minutes of that was spent on the new chemical called 2,4-D. This one weed control chemical alone has rocketted to fame in a relatively short period of time of ten years. It has given new hope to the weed-beseiged farmer, but we must remember that it is only one—no doubt the most important one—of the chemicals that we have at our disposal for weed control at the present time. As a forerunner to this very brief discussion on chemical weed control, I wish to summarize at least a few of the outstanding methods of cultural weed control, upon which the house of chemical weed control is built. Regardless of where we go from here with chemicals these cultural methods of control wil be just as important in the future as they are at the present time. In other words, you just can't substitute good stewardship of the land for a quick easy cure with chemicals. Some of the things which I mention here may not apply to all parts of the country, but as I have looked over bulletins from various states concerning weed control, I believe most of these things are general enough so that every one here will gain some benefit from this sumarization. If from this brief summarization of cultural weed control, and from the bird's-eye view of the chemicals which I will briefly discuss, if from this presentation you glean only a few things which can be utilized by you on your particular farm or in your area, then your time and my time spent here will be well repaid.

In the first place, crop rotations, where they can be used, have a valuable part to play in weed control. With a little planning, a plan can generally be worked out which is detrimental to the life cycle of the weeds in question, and which usually upsets the regular farm rotation very little. This takes planning in advance, so that the program is followed to a successful conclusion; not only started and then abandoned because it does not fit into the regular rotation. As an example, you might cite weeds which tend to build up in pastures, such as vervain, ironweed, goldenrod, and even ragweed, which, when that land is put into cultivated crops tend to disappear very readily without any additional work. Weeds such as foxtails, barnyard grass, pigweed, and lambs quarter which tend to build up in cultivated crops, are quite easily liquidated when such land is put back into grasses and legumes.

In the second place, no good conscientious farmer should ever forget the important place that good seedbed preparation plays in weed control. Timely, thorough, and early preparation of the seedbed, when it can be practiced ,especially if it can be practiced repeatedly, is a wonderful aid toward the control of weeds. Early discing, followed by repeated harrowings in advance of the time that the crops are planted, and again after such clean cultivated crops as corn and soybeans have been planted and before they are up and even after they are up, such repeated harrowings form one of the most important points in a good program of weed control. Furthermore, they are as effective and cheap as many things which we have at our disposal. For the control of many annual weeds, the repeated use of the harrow and the rotary hoe and good seedbed preparation in advance of the crops, will make weed control much easier later on in the season.

In the third place, there may be instances where such specialized crops as flax or sugar beets, which are planted early can be preceded even the preceding year by a program of early plowing and one or two summer fallowing operations to encourage weed seed germination, whose seedlings are then killed out by frost or repeated harrowing. Such early plowing and summer fallowing in advance of the crop has been used most successfully in the production of the flax crop.

In the fourth place, let's never forget the use of the mower along our roadsides, ditch banks, fence rows, and above all, in our pastures. The use of the mower will weaken perennal weeds and will keep annual weeds from going to seed, which after all, is the essence of control. The mower can be used in areas where legumes make it unwise to use 2,4-D.

In the fifth place, don't forget the use of good seed. Seed which is high in germination and high in purity help to eliminate weeds at the source. Man may blame the water, the wind, packing materials, hay, straw, and birds for many of his weed troubles, but he hardly ever looks in the mirror and accuses the man who is staring back at him. Man in his far-flung dealings and operations in agricultural seeds is quite largely to blame for our present-day weed problem, through his extensive use of low-grade, low-quality seed. But we can't put all of our weed troubles at the doorstep of impure seeds. Many of our pastures are overrun with hazelbrush, buckbrush, and brush of various types. I question, however, if any seed analyst has ever found the seeds of hazelbrush, buckbrush, or elms, locusts, or oak in commercial grass seed used for pasture seeding purposes.

In the sixth place, we should never forget the use of good, repeated. shallow cultivations in such crops as corn or soybeans. Shallow cultivation avoids bringing up additional weed seeds into the upper soil layers where conditions for germination are favorable. Repeated cultivations, because weed seeds do not all germinate at one time, and so successive cultivations have to be practiced to keep seedlings from establishing themselves. Shallow cultivation, also, because the less damage you do to the roots of the desirable plants such as corn or soybeans the better able they will be to grow fast and maintain their supremacy over the weeds which are not eliminated by even some of the most careful cultivations. The timing of such cultivations to fit with climatic conditions is also of the utmost importance.

In the seventh place, let's not in the future forget the use of summer fallowing, especially as a method for noxious, perennial weed control. We generally feel that this is advisable only on small areas, because of the additional work involved and the loss which is sustained in the production of no crops.

In the eighth place, we should certainly never forget the use of smother crops. We need here mention only such outstanding smother crops as soybeans, sorghum, sudan grass, millet, or heavy stands of alfalfa. Many of our grasses such as brome grass, orchard grass, timothy, etc., can be used partly as smother crops when we plant them in competition with noxious weed infestations and then aid these grasses in their fight with judicious application of chemicals such as 2,4-D, nondetrimental to the grasses and yet detrimental to the broad-leaved perennial noxious weeds.

Here in a nutshell, then, are eight common methods of cultural weed control, which with minor adaptions can be used in many areas, and judiciously used, form the backbone of weed control. The American and Canadian farmers have never been at a more advantageous position in their fight against one of agriculture's chief saboteurs, weeds, than they are at the present time.

Now let us take a bird's-eye view of the many chemicals which are at our disposal for the control of weeds. The chemicals available today can be compared to a farmer's kit of tools. In that kit there are screw drivers, monkey wrenches, crescent wrenches, pipe wrenches, pliers, every tool designed for a more or less specific use. Some tools can be used for two or three things, and so it is with chemicals. As a good example of this, let me cite CMU, which in rates of 1 to 2 or 3 pounds per acre serves to keep down annual seedling weeds in such crops as asparagus. But the same chemical, used at the rate of 10 to 20 pounds per acre can be used to control such weeds as barnyard grass, foxtail, sandburrs, etc., around lumberyards, oil installations, and outdoor theatres. At the same time, at still larger rates—from 40 to 60 pounds per acre—it can be used to completely sterilize the soil and kill out such noxious perennial pests as quackgrass, Johnson grass, etc. At any rate, in

this chemical kit the farmer finds relief from the weed pests which defy him in spite of his good and best cultural control operations.

In this kit of tools we have selective chemicals such as 2,4-D and 2,4,5-T; chemicals which are soil-sterilizing; and chemicals which are non-soil-sterilizing. There are general weed killing chemicals such as contact sprays, and there are selective materials, which kill only certain things. By altering the dosages you can sometimes change the same chemical and place it in two or three different categories. Let me quickly, therefore, give you a bird's-eye view of some of the chemicals which can aid you in your fight against weeds. No one here will perhaps ever use all of them, but as you listen to this array of chemicals you think of your own farming operations, and where each one of these chemicals can best fit into the weed control program on the land under your jurisdiction.

Let's turn back the pages of time for just 25 years. How things have changed! If we take the Good Book literally as to the three score years and ten, we find that in less than a third of a generation we have made more progress in chemical weed control than we have made heretofore in recorded history. When I first got into chemical weed control work, chemical weed control was relatively simple. There was iron sulphate. Even though it has now been quite largely replaced by other and better weed killing chemicals, a lot of the pioneering work in chemical weed control was done with iron sulphate. Solutions of iron sulphate were used primarily to control mustard in small grain, and dandelions, chickweed, and ground ivy in lawns. It never was extensively used because of its many disadvantages. Nevertheless, it pointed the way to a day of better chemical weed control. Even ante-dating iron sulphate was salt, used by the ancients to control undesirable vegetation. Even quite recently it has been used for the eradication of barberry bushes, for small spot treatments of noxious weeds with resultant ground sterilizing results such as woud occur when patches of Canadian thistles are "salted," combining the effectiveness of the chemicals with the fallowing operations of the hoofs of the animals.

Then came the never too popular use of sulphuric acid for the control of weeds in small grain. It had many disadvantages, but correctly applied it did control, selectively, mustard in small grain. And even in these early days with iron sulphate, sulphuric acid, and salt the directions had to be followed closely if desirable results were to be obtained. I mention this, merely, because many times we are inclined to believe that careless application of chemicals dates back only to the advent of 2,4-D. It has been present since man first started using one chemical to control weeds. Such things as spray fumes, spray drift, corrosion, overdosing, etc., have been present ever since man started applying chemicals to selectively or totally kill weeds.

As time went on, sodium chlorate was added to the list of weed control chemicals. Later on came a companion compound known at Atlacide. Regarded quite largely as non-selective herbicides, they required two or three applications generally before complete control was accomplished, depending upon situation, weed, moisture, etc. They were really the first chemicals which were used on an extensive scale. They had many disadvantages, but their main advantage was that they fought for us a delaying action on many of our noxious weeds, giving us time to bring better weapons into the fray. Many farmers were on the alert and kept their lands free of noxious weeds by means of sodium chlorate and Atlacide. Otherwise, the infestations would have been infinitely worse by the time other chemicals came along which did a better job. Sodium chlorate and Atlacide were used as translocation herbicides to spray on the plants, were non-selective, killed everything with which they came into contact, even the soil for varying periods of time.

Then along came such materials as Carbon Bisulphide, Chloropicrin, and Tetrachlorethane, designed to be injected into the soil in heavy weed patches and designed to kill the underground roots of such weeds. They were expensive, laborious to apply, hazardous to handle, but nevertheless, effective.

Then came another chemical, Ammate (ammonium sulfamate) developed especially for the control of poison ivy. We found also that it was very effective for the control of leafy spurge. Later on, its usefulness for application on brushy plants was ascertained. It served to control sprouts from stumps, and it could be sparingly used on poison ivy and quackgrass under well-established trees where it had never been possible heretofore to use effective chemicals. This was an advantage over Sodium Chlorate and Atlacide. It is still extensively used for all of these purposes, plus the control of weeds in sidewalk cracks, around well-established trees, house foundations, etc.

Then along came the dinitro sprays, first of all the selective materials, designed for the control of annual weeds in flax and small grain. They were just coming into more and more extensive use when other more promising selective weed control materials came along. After the selective dinitro materials had been developed, then came the dinitro contact materials, which controlled vegetation by "mowing it chemically."

About the same time came another chemical, namely, pentachlorophenol, still used extensively for the treatment of lumber, but used in those early days as a chemical mower, alone or in combination with sodium chlorate.

About the same time along came the borax compounds, either in the regular, then in the concentrated forms, lately in conjunction with other chemicals such as 2,4-D and CMU. These were adapted for soil sterilizing purposes, and for the spot treatment and control of deeprooted noxious weeds. They were and are being used by railroad companies on right-of-ways, bridge abutments, etc., and there are several forms and combinations being used at the present time.

Along with World War II and the lack of labor in the carrot production areas, the use of herbicidal oils grew by leaps and bounds. These oils made it possible to selectively kill weeds in such crops as parsnips, carrots, parsley, caraway and dill without injuring the desirable crop plants.

Later on came potassium cyanate for lawn weed control, the use of PMA for the control of lawn weeds, and the use of water white kerosene for the control of dandelions and crabgrass in lawns.

It remained for 2,4-D, however, to assume the role of giant killer among the weed killing chemicals so far enumerated. It was here in Omaha, 11 years ago, that this astounding chemical was first mentioned to a small handful of regulatory, industrial, extension, and research personnel, many of whom are here today. Many of the things which were nebulous speculations 11 years ago have become reality, and I dare say have surpassed our fondest expectations. This one chemical alone has assumed monumental proportions in chemical weed control today. From a few pounds in 1944 to around an annual consumption of around 40,000,000 pounds yearly is truly a remarkable story. The chemical has been investigated and re-investigated, and while it has hazards and faults it truly has become the miracle weed-killer. In 2,4-D alone and in its sister compound, 2,4,5-T, American farmers got a new lease on life in their fight against weeds and brush. For the farmer and homeowner, it means cheaper and more effective control of weeds than was ever possible before. To properly evaluate the good that these two chemicals alone have done would require voluminous books. American and Canadian farmers have taken these chemicals and are using them in an ever expanding program of weed control. The pictures will show them being used for the control of weeds in lawns, cemeteries, small grain, pastures,

XUM

roadsides, fence rows, in corn and flax. Their selective ability to seek out many broad-leaved weed robbers, while at the same time being non-detrimental to grassy plants is well known. Now many of our grasses such as brome grass, orchard grass, timothy and bluegrass can be used in a cultural way to help control noxious weeds and their usefulness can be implemented by means of the selective chemicals such as 2,4-D and 2,4,5-T. The fact that the usage of these materials is still expanding for the control of weeds and brush along county, trunk, and local roads, under utility lines, along railroads, and on the farm is mute evidence that farmers, officials, and utility companies have really taken these chemicals to heart. 2,4-D and 2,4,5-T used in combination as "brush killer" either as a foliage spray or in fuel oil can be used for foliage treatments, for basal treatments, stump treatments to prevent resprouting in the control of unwanted brush. While admittedly there are no perfect weed control chemicals, and 2,4-D isn't perfect, since they have to be used with care, judgment, and discretion, nevertheless these chemicals alone will go a long way toward making farming more profitable, easier, and freer from weeds than has ever been the case before.

And along with 2,4-D and 2,4,5-T came other reinforcements to aid the farmer in his fight against weeds. Some of these are for general purposes, others are for specific purposes. Some have been with us for quite some time, others are relatively new. On many of them, still additional work needs to be done to ascertain just where they will fit into the weed control picture. Coming into more extensive usage at the present time are such chemical weed-killers as MH, dalapon, TCA CMU, and amino triazole. Additional ones are IPC, CIPC, DNBP, 3,4-D, 2,4,5-TP (Silvex), naphthyl phthalamic acid, endothal, sodium isoproyl xanthate, SES, trichlorobenzoic acid, CDAA, CDEC, and CDEA. Some are coming into common usage, others are relatively new and largely experimental. For instance, CMU is in common usage for the control of small patches of noxious weeds, brush, and soil sterilization in such areas as around outdoor theatres, lumber yards, oil installations, power stations, etc. TCA can be used for the control of quackgrass and other perennial grassy weeds, primarily as a soil treatment. Dalapon as a foliage spray can be used to control many obnoxious, perennial grassy weeds. At higher dosages it will kill such plants as quackgrass, whereas in lower dosages it can be used as a selective spray in such plants as flax. Almost any chemical mentioned heretofore has tremendous possibilities. Every chemical can actually have several uses, depending on what the farmer wants done. In some instances, a light dosage of a chemical will selectively kill weeds; at heavier rates the same chemical may be a total killer of all vegetation. The time is here when an individual farmer can look at his own specific weed problem, and practically decide to use a specific, tailor-made chemical to help implement his cultural weed control practices. Each chemical has tremendous possibilities to make your job of weed control easier, simpler, more effective, and more profitable. Many of these chemicals, undoubtedly, have myriads of uses which only additional testing will bring out. Chemicals still in the test tube and yet unborn will aid our chemical weed control program in the future. Of all the chemicals tested, many are discarded in favor of better materials. Whether they stay on the market and "fill the bill" for which they are intended will depend upon how well they accomplish the task for which they are designed. The ones which prove "best by test" will be added to our chemical weed arsenal of the future.

I have tried to illustrate the uses of some of these chemicals by means of pictures. In a quick survey of this type, it is impossible to convey to you all of the uses for a certain chemical. I hope by this presentation that you have realized that some of these chemicals can aid you in your fight against weeds, whoever and wherever you are. Each specific farm, due to land topography, location, climatic conditions, crops grown, type of weed infestation, etc. is a specific problem. You as operators of land infested with weeds have a difficult problem in the intelligent choice of "which chemical to use where." Remember that chemicals are implements to better, cheaper, and more effective weed control. All chemicals have their merits and their weaknesses, their advantages and disadvantages, their safe points and their hazards. Many of them will not accomplish miracles over night. Most of them are best used as implementing good cultural weed control. They must be used intelligently according to the directions, for the specific tasks for which they are intended, adapted, and designed. If they are used in that manner, they can provide an effective, efficient, and easy way to better weed control. I hope, too, above all else, that you have gotten a new sense of hope in your fight against weeds, and a renewed will toward a better stewardship of the land. Once you realize how with a little planning and a little foresight you can adapt these cultural and chemical methods of weed control to your individual use, then your task of weed control will become easier and more profitable. Remember that with all of the advantages of good cultural practices and the best chemicals the world has ever designed at our disposal, weed control still is no easy task. If it were, it would have been accomplished a long time ago. By adopting modern and up-to-date and specific methods of fighting weeds on your particular areas, utilizing the latest information on chemical and cultural weed control, you will be rewarded with greater stewardship of the land, higher yields, and greater profits. Added income is in turn reflected in a higher standard of living for you and your family.

[1] Iowa State College Extension Service, Ames, Iowa.

ARE YOU KILLING YOUR BINDWEED? WHY NOT[1]

W. M. Phillips[2]

The title given on your program poses a question which we shall not answer fully this afternoon. Perhaps however, we can ask the question in a different way. Why should you control your bindweed? Certainly we know of no easy way to eliminate this serious weed pest. First, let us assess the trouble bindweed causes on our farmland, and then try to arrive at some conclusion concerning the advisability of spending time and money to control the weed.

From 1936 to 1947 a series of experiments at the Fort Hays Experiment Station, Hays, Kansas, indicated the effect of field bindweed on the yield of various crops grown in the area. Cultural practices which were followed in these experiments were comparable to average farm practices. Half of the area used was infested with bindweed and the yields were determined separately on infested and non-infested areas for each crop. Grain yields of wheat, rye, barley, oats, kafir, and milo, and forage yields of drilled sorgo and sudangrass were obtained each year. The 12 year period included a wide range of growing conditions. Yields in some years were extremely low for nearly all of the crops. In other years the yields were quite high and the 12 year average indicated that, over the period, nearly average yields were obtained on land not infested with bindweed.

Results of these experiments showed that rye was one of the most successful competitors with bindweed. The average reduction in rye yields due to bindweed infestation was 20 per cent. Wheat yields were reduced an average of 30 per cent during the 12 year period. Yields of kafir and milo were seriously reduced nearly every year. The average reduction for milo was 78 per cent. Since milo is normally planted about June 1, it

XUM

must compete with bindweed throughout the growing season and, therefore, is not a satisfactory crop to grow on infested land. On the other hand, wheat and other small grain crops actively compete with bindweed from about May 1 to harvest time.

What do these figures mean in terms of income to the farmer? Let us take wheat as an example. The 12-year average yield on non-infested land was 17.2 bushels per acre while on infested land the average was 12 bushels per acre. This is a difference of slightly more than 5 bushels per acre per year in favor of clean land. This quantity of grain would soon pay the cost of bindweed control and thereafter enable the farmer to realize the full productivity of his land. Most farmers certainly would welcome a new wheat variety which would increase yields 5 bushels per acre. Yet many farmers are sacrificing wheat yields because of heavy bindweed infestations.

While reduction in crop yield is the most apparent detrimental effect of field bindweed, it is not the only problem that the weed presents. In certain cases there may be considerable difficulty encountered in harvesting a crop from land heavily infested with bindweed. If a small grain crop is harvested with a combine, the green weed material may increase the moisture content of the grain and make threshing more difficult. Also, bindweed seed is often mature at about the same time small grain crops are being harvested. Those of you who have tried to clean a combine know how difficult it is to remove all of the seed from that machine. Thus, harvesting operations carried on in an infested field may spread bindweed seed to other fields.

Control of a noxious weed, such as field bindweed, can well be discussed in two parts: first, the control of rather small areas of the weed and second, the control of the large infestations that cover many acres. We feel that one of the most important factors in a control program is the elimination of small areas of the weed. Several methods may be used to control these patches but in many regions soil sterilizing chemicals have proved highly satisfactory. It is recognized that soil so treated will be unproductive for one to three or more years. Also, these chemicals are rather expensive when considered on a cost per acre basis, but usually the cost of controlling a small patch is not a serious consideration if it is possible to prevent the entire field from becoming infested. Likewise, it is felt that the small area of land that will be unproductive as a result of the chemical application is not a serious factor when viewed from the standpoint of prevention of spread.

Several chemicals are satisfactory for soil sterilizing purposes. One of the oldest, and still in common use, is sodium chlorate. This chemical when applied at 4 to 6 pounds per square rod is one of the most dependable weed control chemicals available. Fall treatments often give better results than applications made at other times. However, sodium chlorate may be applied in the spring or early summer. If application is made during the hot summer months, it is advisable to increase the rate of application. Various boron compounds have been widely tested for their effectiveness in controlling field bindweed. Concentrated Borascu at 16 to 20 pounds per square rod often gives results similar to those obtained with sodium chlorate. Mixtures of boron and sodium chlorate also may be used. CMU has been tested for several years, and under certain conditions, excellent bindweed control has been obtained with this material. Since CMU at high rates is rather persistent in the soil, it does not seem advisable to use the material extensively on agricultural land.

Some new chemicals now being tested show considerable promise but certainly we do not have sufficient information to make recommendations at this time. The use of high rates of 2,4-D, that is, rates from 40 to 80 pounds per acre, has been suggested as a means of controlling small areas of noxious weeds. These high rates of 2,4-D have given satisfactory results on some weed species. However, the results on field bindweed do not justify a general recommendation at this time.

The use of 2,4-D at conventional rates, that is ½ to 1 pound per acre, has some disadvantages when compared to the soil sterilizing type materials. Many times the small area of bindweed is located in a large field and there is a tendency to spray the area with 2,4-D, plant crops, and then forget the patch. Seldom, if ever, do we get complete eradication with one application of 2,4-D. This necessitates retreatment and, unless the area is carefully marked it may be difficult to locate in the larger field. By using a soil sterilant, the bindweed area is identified by lack of vegetation and may be easily inspected. Even when using soil sterilants it is usually necessary to have follow-up treatments to eradicate the weed completely. These retreatments, after the original application of such soil sterilants as sodium chlorate or boron compound, need not be made sooner than 18 months.

The control of large areas of bindweed offer, I believe, a more serious problem than the control of small patches. Some years ago, it was hoped that 2,4-D would be the answer to the control problem offered by large areas. 2,4-D is, of course, an excellent chemical and it will enter into this discussion of large areas of field bindweed. However, I believe that, in a successful control program, it will usually be necessary to practice some phases of cultural control also. I do not mean that I advocate the return to the large scale intensive cultivation program which was the only practical way of controlling such weeds as bindweed prior to the discovery of 2,4-D.

An intensive cultivation program has merits, but it also has a number of disadvantages. First of all, cultivation operations must be done at the proper time. That is, if the program calls for cultivation every 14 to 18 days, the operation must be performed very nearly at that interval. A longer period of time between cultivations will allow the weed to make some recovery. This intensive cultivation schedule is often rather difficult to follow. Another serious disadvantage of intensive cultivation is that the land is left bare for one or even two growing seasons. This permits wind and water erosion in many areas. But use of proper tools it is possible to reduce the danger of erosion but, at best, after a full season of intensive cultivation, the soil is quite loose and subject to blowing or washing. The loss of one or more crop years because of intensive cultivation is often a criticism of the method. However, if the weed in question is controlled, returns from the land in subsequent years will generally far offset the loss of one crop year.

Before proceeding I should like to define the term intensive cultivation as I shall use it. Intensive cultivation refers to repeated tillage which will eventually kill most deep-rooted perennial weeds. This cultivation can be done with a variety of implements. One of the most satisfactory is the duck-foot or sweep type cultivator. One disadvantage of the duck-foot type implement is that, in heavy soil, it tends to create a hard layer a few inches under the surface. Occasionally, it may be necessary to use some other tool, such as the moldboard plow to break this hard layer. One of the most important aspects of intensive cultivation is that the machine must be adjusted so that all of the roots are cut each time the soil is cultivated.

Cultivation from 4 to 6 inches deep appears to be most economical from the standpoint of rapid eradication of the weed and the cost of tillage. The intensive cultivation operations may be started either in the spring, with the first cultivation about 2 weeks after bindweed emergence, or after small grain harvest. As a general recommendation cultivate at two week intervals for a period of 2 to 3 months. Then the period can safely be lengthened to three weeks. Such intervals between cultivations have given more rapid control of the bindweed than when the cultivation was done each time the bindweed emerged. This practice of black fallow has required more cultivations for eradication than when the weed is allowed to grow for 8 to 12 days after emerging.

XUM

A program of intensive cultivation will normally require two growing seasons to eradicate an established stand of bindweed. Thus, the farmer loses two crop years and leaves his land subject to wind and water erosion for a rather long period. Methods which employ a combination of intensive cultivation and competitive crops overcome some of these disadvantages. In many cases only one crop year will be lost during the control program, and in some areas, this one year of summer fallow will result in larger yields in succeeding years.

One of the most successful methods of bindweed control by cultivation in the Hays, Kansas, region is the use of one season of intensive cultivation followed by one or two years of wheat and then, if necessary, an additional season of intensive cultivation. Following this sequence of operations the bindweed is usually well under control. The land should be cultivated at 2 to 3 week intervals whenever a crop is not growing. Cultivation between harvest and seeding is as important as during the summer fallow period. The program may be started either in the spring or after small grain harvest and the cultivations should be continued until September 15 or October 1. This may necessitate some delay in wheat seeding. Summer-planted competitive crops may also be used. Sorgo, sudangrass or millet planted in closely spaced rows have been excellent competitors in a bindweed control program. It is recommended that a period of cultivation precede these crops If a heavy stand of the competitive crop is not obtained, it is advisable to destroy the crop and continue the intensive cultivation throughout the summer growing period.

Many experiments have been conducted to determine the effect of 2,4-D on field bindweed. In summarizing the results it appears that the chemical, if properly used, will offer considerable bindweed control but seldom will result in bindweed eradication even with repeated treatments. For the most consistent results, it is believed that one pound of 2,4-D per acre should be applied to bindweed. The ½ pound rate has, in some cases, been nearly as effective as the higher rate, but often has given less reduction in stand. Under some conditions it may be advisable to use ½ pound when a crop such as wheat is growing on the land. A specific date of application is not as important as is a vigorous growth of bindweed. Favorable growth conditions often occur in the spring at the time bindweed is in the bud to bloom stage. Fall applications of 2,4-D have been satisfactory in some cases.

When it became evident that 2,4-D alone was not giving satisfactory bindweed control, experiments were initiated to determine the place this chemical might have when combined with competitive crops and intensive cultivation. Good results have been obtained when the chemical was applied about 30 days following a one to two month period of intensive tillage. Cultivation should be resumed when bindweed regrowth appears. Thus it is possible to substiute 2,4-D for some cultivations. The chemical has the advantage of giving greater stand reductions earlier in the control program than do intensive cultivation and competitive crop methods used alone. Also, the cost of the operations may be lower if 2,4-D is used to replace several cultivations. However, the use of 2,4-D in a cultivation program probably will not greatly hasten the eradication of the weed. It should be pointed out that land subjected to bindweed control measures should be watched carefully for several years to see that the plants which escape the treatments do not reinfest the entire area.

You may note that I have said little about the use of 2,4-D in growing crops. We recognize that this chemical, especially the amine salts, may be used on crops such as winter wheat without serious damage to the crop if the application is properly timed and the rate of application is not excessively high. However, rates of less than one pound 2,4-D per acre may not give maximum control of bindweed. Another disadvantage is that by the time the bindweed is at the proper stage of growth for treatment the wheat is rather tall and may intercept part of the spray. However, applications to growing crops may be useful in preventing bindweed seed production and in reducing harvesting difficulties.

One of the most serious problems in a bindweed control program, and one of the most difficult to solve, is the problem of bindweed seed which remains in the soil after the established stand has been eradicated. These seeds may remain viable for many years and may be a source of reinfestation. Care must be taken to prevent seedlings from becoming established as perennial plants. A seedling can be killed with one cultivation until it is 4 to 5 weeks old. After than more than one cultivation may be necessary. The seedlings are quite susceptible to 2,4-D so this chemical may be substituted for some cultivation in the seedling control program. It may, in some instances, be used to control seedlings which emerge in a thin stand of a competitive crop and to kill bindweed seedlings in a stand of perennial grass. Completely ridding infested fields of bindweed may require 30 or more years of rigid attention to a special program of soil management.

Crops and cropping systems that have proved quite satisfactory for bindweed seedling control, include the sowing of winter wheat or close-drilled sorghum, or a rotation of wheat, row sorghum, and summer fallow, supplemented with monthly cultivations when the land is not in crop. Leaving small grain stubble idle and uncultivated until spring will permit bindweed seedlings to become established.

Seeds in the soil are potentially dangerous in other ways. It is possible to transport seed from an infested field to an uninfested area on cultivation equipment. If I may speak for personal experience, I assure you it is rather disconcerting to see bindweed seedlings suddenly occurring in a field which was assumed to be free from the weed. The only explanation we could offer was that the seed was transported by farm machinery from an infested area.

I hope I have sufficiently stressed the problems of bindweed control so that those of you who do not now have bindweed will do everything possible to prevent this weed from becoming a problem on your farm. My first suggestion in this prevention program would be to learn to recognize bindweed seed. Then before planting any crop on your farm I would suggest that you examine the crop seed carefully to be certain that no bindweed seed is present. Of course the various state weed programs and crop certification agencies have done much to prevent the distribution of bindweed seed in crop seeds. The second important factor which I touched on briefly is the cleaning of harvesting machinery. I think we cannot stress too strongly the care which should be taken before any machine which might carry weed seed is permitted in a field free of noxious weeds.

If bindweed is growing on your farm I hope you will inaugurate a control program and follow it until the weed is under control. It has been said many times, "It costs less to kill weeds than to let them grow."

---

1 Contribution No. 100 Ft. Hays Branch, Kansas Agricultural Experiment Station, Hays, Kansas.

2 Associate Agronomist, Field Crops Research Branch, A.R.S., U.S.D.A. and Assistant Professor, Kansas Agricultural Experiment Station, Hays, Kansas.

WHAT IS THE FUTURE OF WEED CONTROL?

L. M. Stahler[1]

In making a reasonable prediction of the future development of any program such as that of our main interest here, we must equally consider both real and relevant facts. The past development and present state of weed control programs are the factual evidence. A knowledge of the parallel trends in development of insect and disease control practices by agricultural producers—or the trends in use of commercial fertilizers—is relevant in indicating the wide acceptance of improved productive practices.

What has been the development in weed control? We need go back only 20 years to reach the beginning of this development. Before 1935 there were not over half a dozen people in the U. S. devoting full time to weed control and this includes salesmen devoting full time to selling chemical herbicides. State regulatory agencies were armed with police power which they exercised more widely than they do today—but while they properly irritated farm operators they seldom could offer reasonable control or eradication measures.

Weed control research was not an item in the program of any of our agricultural experiment stations. A few pioneering agronomists had developed an academic interest in weed control as an unscheduled extracurricular activity. Most extension specialists of our experiment stations first had no positive information to take to the farmer and often rationalized the problem of weed control as evidence of poor husbandry and therefore an individual personal problem of the farmer which reflected his unfitness to till the soil.

While most states in this area then had seed laws, they were ineffective in preventing local movement of crop seeds loaded with noxious weed seed. Feed grains and forage carrying weed seed moved unhindered. Commercial combine harvesters moved freely from Texas to the Prairie Provinces of Canada and seeds of such weeds as bindweed went along for the ride.

The rapid and widespread development of bindweed from Texas to Western Canada probably was the most important single factor in awakening the wide interest in weed control which has developed to the extent well evidenced by the attendance at this 12th Annual meeting of the NCWCC. Bindweed became the limiting factor in crop production over millions of acres of our land. In addition, drouth plagued the entire North Central area at that time.

In early 1936 with Mr. Kephart who then headed up the U.S.D.A. weed control group, I traveled through southern Minnesota, South Dakota, Nebraska and Kansas as a new employee of the U.S.D.A., surveying the field in which I was to work for almost 20 years. If it had not been for the enthusiasm of such pioneers as Mr. Kephart, Dr. Keim of the Univ. of Nebraska, Prof. Zahnley and Ted Yost of Kansas and Prof. Al Larson of Minnesota, I would have promptly resigned at the end of that initial survey tour. I will recall the discussion we had with a farmer near York, Nebraska, who emphasized that he and his father before him had operated their homestead through hazards of blizzards, chinch bugs, grasshoppers, drouth and ruinous farm prices—always looking forward to the "better years". But with bindweed there was no future and "nobody seemed to give a damn about doing anything to help him". At that time he was almost right—I am sure a general conference of those interested in weed control in NCWCC area would not have assembled 50 people.

In the past 20 year period weed control has become established as an essential part of agricultural production techniques in our farms, in our agricultural experiment stations, in our state regulating agencies and in the agricultural chemical industry throughout the U. S. and Canada more fully than in any comparable geographic area in the world. Further, the Prairie Provinces of Canada and the North Central States have set the pace for North America in these developments. And in those states where bindweed became such a serious problem in the early 30's we now find the most highly organized and useful state weed control programs. Minnesota, Kansas, Iowa, Nebraska and South Dakota—all have active programs that differ widely in organization, being similar only in that they operate under the authority of their respective state departments of agriculture, have the full cooperation of their state experiment stations, and all have become established as highly practical, essential service organizations for the benefit of the agricultural industry within their operating area. The advice and services of these state weed control organizations is extended to, and of real value to other than farmers themselves—our highway departments, communication and power transmission systems, our railroads—all make use of and profit by the technical knowledge and available services of these efficient organizations. The people in the agricultural chemical industry—from research to sales—get invaluable assistance in bringing new and more efficient herbicides from the experimental stage of development to accepted field use.

The initial development of these fine state programs—based on technical assistance but backed by police power—has greatly stimulated the weed research programs of the agricultural experiment stations in the respective states. Today, the states with the strongest action programs have the strong weed control research teams working at their experiment stations. It is of common occurrence with this type of close cooperative effort to have new practices developed by research in wide field use before any type of formal publication of the experiment station appears.

Is there real, statistical evidence of the success of our weed control programs? Dependable figures are all too few, but where available, highly significant, and I gathered these at random. From an accurate source in Canada—Henry Wood of the Manitoba Weeds Commission—we have data to show an increase in acres treated in the Western Province with 2,4-D from 500,000 in 1947 to 14,000,000 in 1955. In addition, he indicates usage of 1,500,000 lbs. of borates and chlorates for perennial weed control in 1955.

Here in the U. S. where accurate acreage figures are conspicuously lacking, we have from the U.S.D.A. data to indicate that we spent in 1955 some 48 millions of dollars for herbicides and commercial application and that 75% of this investment in weed control was made by farmers in the NCWCC or Western WCC areas. We know that since 1945 U. S. and Canadian farmers have purchased almost 1,000,000 field sprayers for application of herbicides.

Have our weed control programs kept pace with other comparable developments in agriculture? The highly publicized development in use of commercial fertilizers should serve as a fair comparison here. And we will make our comparison based on nitrogen—the plant food element that has shown greatest use gain. In 1950 1,000,000 tons of nitrogen in various forms were applied to U. S. cropland as commercial fertilizer—this year approximately 2,000,000 tons were used—a gain of 100%. In the same period production of 2,4-D acid increased from 14 million pounds to approximately 30 million pounds in 1955—an increase of almost equal parallel to that of nitrogen fertilizer usage. But will the growth curve of weed control practices continue to rise, or have we about reached a saturation point, or the point of diminishing returns on our efforts in research development and use of better weed control practices?

Results of a recent survey show that despite the fact that we are justly proud of our technological advances in agricultural production, we have made only a start in our battle with crop pests. Actually in 1955 only 1/6 or

XUM

about 60 million acres of our total crop acreage in the U. S. received any pesticide treatment whatsoever and of this acreage, ½ or about 31 million acres was treated with chemicals as herbicides. It is evident that while our growth has been vigorous, and our present condition is robust and healthy, we are yet infants, and further growth is inevitable.

As either a youngster or a program grows it develops new and more mature characteristics and useful talents. An indication of the broader usefulness and developing maturity of weed control programs in general can be well established by the direction and thought of the fine organizations behind your weed control programs in Nebraska.

One of the finest weed control research teams in the U. S. at your university at Lincoln is carrying out a program keyed to the problems of the farmers of the State of Nebraska. New chemical herbicides are currently and widely field tested to determine their usefulness. They are doing intensive work on chemicals for control of weeds in crops such as soybeans, flax, seedling alfalfa, and such specialized crops as safflower —crops sensitive to such herbicides as 2,4-D. Only recently have they screened several new compounds that show real promise for control of both grass and broad leaved weeds in these important crops. This group emphasizes research on grass weeds—foxtails, barnyard grass, crabgrass, of irrigated land and downy brome which is such an important pest in your western wheat land. They are pioneering in research on chemical summer fallow—theoretically a highly practical soil and moisture conservation practice for future development. Their joint research project with several divisions in the Agricultural College on agricultural aviation is unique, timely and practical.

In your State Dept. of Agriculture, your Division of Noxious Weeds directs the first state program organized on the basis of voluntary district participation. This type of organization is at the same time unique and typical of Nebraska and its ultra individualism. And this organization has been highly successful as evidenced by the great proportion of your state area presently carrying out noxious weed control district programs. A strong point in your state program has always been the hand-in-hand cooperation with your agricultural experiment stations. This close working relationship has been highly advantageous to farm cooperators in your organized districts in bringing them the latest in new techniques, herbicides, and practices for efficient weed control.

I have known Dwight Lambert, Chief of your Noxious Weed Division, for many years and likewise Neal Shafer who masterminds the fine weed control research group at the University. In considering this discussion with you, I asked each of them to consider the most important immediate need in furthering their already extensive joint programs. Independently each praised the other's efforts and accomplishments in the program and further each independently emphasized the need of a third group to most efficiently serve the present and future needs for weed control in Nebraska—extension. They both were high in praise of the work done by John Furrer, Extension Agronomist at the Nebraska Agricultural Experiment Station, but emphasized that John's influence alone could not be extended far enough in an area the size of the state of Nebraska and that the great need in extension development was presently at the farmer cooperator level especially in areas where weed control districts had not to date been established. Both felt that research developments and information were reaching too few farmers and with too great a time lag. The fact that their statements of this need for more complete, more rapid dissemination of latest weed control information is based on requests of a broad cross section of farmer cooperators is significant in forecasting the future growth of your weed control program. It is further indicative of trends throughout much of the NCWCC area.

The growth of this great development in weed control is already deficient in one very important element—trained personnel. We in industry are acutely aware of this in finding well trained college graduates for our expanding research and sales staffs. The Universities and agricultural experiment stations are short on the highly trained personnel to carry out their research programs and to train students in the technical branches of botany, physiology and chemistry so necessary in modern weed control developments. Each year new chemical herbicides, new techniques in application and new uses are developed. In order to continue bringing these new aids to you, all agencies—industrial, research, extension and regulatory, need more ample sources of well trained young men.

In looking back at the past 20 years of weed control developments and, as here, considering what future developments will be, I am always impressed by the headline statement used on the monthly edition of the South Dakota Weed Fighter; the internal news letter sent out by Charlie Gilbert of the State Weed Board of South Dakota. If your state program, or the program of the NCWCC measure up to the principles of this statement, there should be no question as to their future growth and development. I quote, without Charlie's permission, "Any program that pays for itself on a current basis several times and, in addition, helps protect the future productivity of our land, is a good investment."

[1] Pacific Coast Borax Company, Los Angeles, California.

WEED AND BRUSH CONTROL IN PASTURES[1]

M. K. McCarty[2]

Much is being said and done about weed control in all our major crops and cropping areas. Yesterday many of you heard about weed control in everything from cranberries in Wisconsin to potatoes in the high mountain valleys of Mexico and control of perennial weeds at Saskatoon. However, the place of weed control in our pasture lands was not given much coverage.

In 41 counties of eastern Nebraska having about 14,200,000 acres in farmland, one acre out of every six is devoted to pasture. This same ratio would apply fairly well for western Iowa and northeastern Kansas. Taking the entire North Central region, comprising fourteen states from Ohio to the Northern Plains, the ratio is closer to one acre of every three and amounts to roughly 145 million acres. Although there are no statistics to show the proportion of this acreage that is run-down, weedy and producing far less forage than possible, we all know that it is much higher than it should be.

Computing the losses due to weeds in pasture has been a task apparently avoided due to lack of good information upon which to base estimates. However, a recent U.S.D.A. estimate based on a 10% loss due to weeds sets the total loss on pasture and range lands in the United States at slightly over 470 million dollars a year. It is no exaggeration to say that our need for information about weed and brush control in pastures is great.

Following preliminary work in the late 1940's, Dr. Dayton L. Klingman[3] set up experiments on weed control and buckbrush control in pastures near Lincoln in 1950. My remarks this afternoon will be based on progress made and data obtained from these experiments in the ensuing six years. These data show that methods are currently available to secure satisfactory weed and brush control and that valuable increases in desirable forage will be obtained in connection with reduction of the weedy species.

A weedy pasture was selected on a farm 10 miles south of Lincoln, Nebraska, for the study of weed con-

trol. The predominant weeds were ironweed, false boneset, dandelion, hoary vervain, many-flowered aster, annual ragweed, hairy chess and prairie tripleawn. The main desirable grass was Kentucky bluegrass with scattering occurrence of side-oats grama, sand dropseed and big bluestem. Weed control treatments were (1) check, (2) mowed in June, (3) mowed in July, (4) 2,4-D ester (1 pound per acre) in June, (5) 2,4-D in July and three sets of plots plowed and reseeded to adapted grasses or mixtures. Smooth bromegrass, intermediate wheatgrass and a warm season mixture of big bluestem, switchgrass, sand lovegrass and blue grama were seeded in the plowed plots. The grasses were seeded in the spring of 1950 on land fall plowed in 1949. The seeded grass plots were sprayed with 2,4-D ester in the 1950, '51 and '52 seasons with ¼, ½ and 1 pound per acre, respectively, except that mowing was substituted for spraying in the warm season grass mixture in 1950. Applications of 1 pound per acre of 2,4-D were continued on these plots in 1953 and 1954. Three levels of grazing management, (1) protected from grazing, (2) deferred and rotational grazing and (3) grazed as usual, were superimposed across the weed control treatments.

Counts of all broad-leaved weeds were made in 5 permanently located quadrats per plot, beginning in 1950 before the initial treatments and continuing each year since. In succeeding years, the counts were made prior to that year's treatment and reflect the amount of control accomplished by the preceding treatments. Grass composition was followed by means of 12 line transects per plot. Total production and consumption by grazing animals was determined by means of clipping caged (protected) and uncaged plots. The clipped material was hand separated into three classes of vegetation; desirable grasses, weedy grasses and broad-leaved weeds.

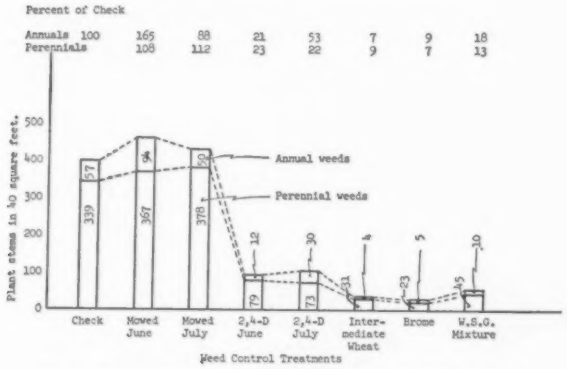


Fig. 1. Effect of weed control treatments upon number of the important annual and perennial broad-leaved weeds in 40 square feet in June 1955.

Figure 1 shows the overall effect of weed control treatments on the important perennial and annual weeds. Seven perennial weeds are included in this summary which shows the mowed treatments having slightly greater numbers of weeds than the check and with very good control being obtained in the sprayed plots. Dandelion numbers have increased markedly in the six years of the experiment in the mowed plots with the control of other perennial weeds ranging from poor to fair. Ironweed, the major perennial weed in the pasture, was reduced almost 50% by early mowing but only very slightly by late mowing. On the other hand, spraying with 2,4-D reduced ironweed by 95% or better with the early spray showing some advantage over the later date. False boneset had slightly increased numbers under the two mowing treatments as compared to the check but showed about 65% control where sprayed with 2,4-D.

The best weed control was accomplished by plowing, reseeding to adapted grass species and following with 2,4-D for continued control. Control of nearly all species but dandelion in these plots has been 95% or better. Because a constant source of dandelion seed surrounds these plots, late summer and fall germination allows young dandelion plants to be established each year. These are included in the spring counts which come prior to that year's weed control treatments.

Killing weeds does not show immediate profit if it does not mean an improvement in the crop or increased returns in some form. Figure 2 shows percent basal density of all grasses as affected by weed control treatment. Both mowing and spraying have been accompanied by increases in basal density of the grasses, particularly the desirable forage species. The amount of increase has been greater for the sprayed plots than for the mowed plots as might be expected by the greater effectiveness in weed reduction.

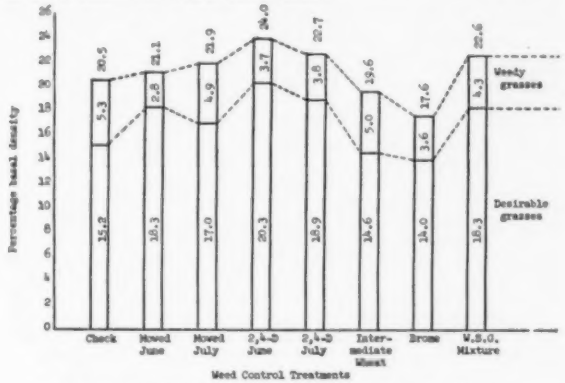


Fig. 2. Percentage basal density of grasses in June 1955 as affected by weed control treatments.

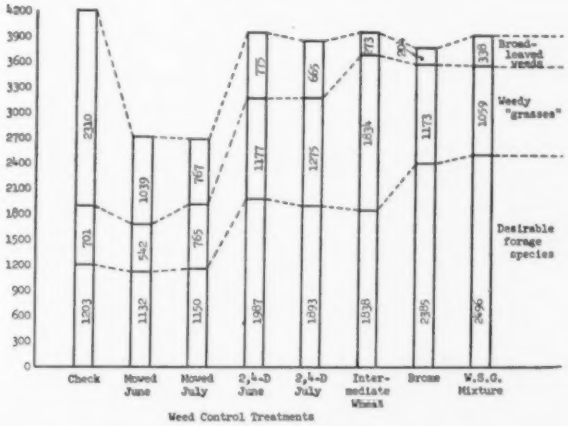


Fig. 3. Effect of weed control treatments upon the total production of dry matter per acre, data are average of 1951, '52 and '53.

Figture 3 shows what happened to total production by vegetative classes as affected by weed control treatment. These data are an average for the 1951, '52, and '53 seasons for both grazed as usual and deferred and rotationally grazed. The two mowed treatments are low because the material dropped during the mowing operation for weed control was not salvaged for harvest. Except for these mowed plots, the total production of all dry matter was nearly the same as the check plot. The important point to consider is the distribution between vegetative types. The check is 55 percent broad-leaved weeds while the sprayed plots have been reduced to 20 percent or less. The three reseeded plots average less than 8 percent broad-leaved weeds. With the total pro-

duction nearly the same across all plots, this marked reduction of broad-leaved weeds has been made up for by the grasses, and to a considerable extent by the desirable forage species.

Another large source of loss in pastures is the occurrence or presence of infestations of brush species such as buckbrush. The brush in these areas ultimately becomes so thick that no grazing use is made by livestock within the individual patches. In 1950 a study was started to evaluate the effectiveness of mowing as compared to spraying with 2,4-D amine or ester for the control of buckbrush. Spray treatments were made on five dates: May 14, 21, 28, June 28, and August 16 with mowing included only on the May dates. The buckbrush was in full leaf with regrowth shoots 4 to 10 inches long by the earliest treatment date. Results given in the following table show the effect of 4 years' treatment, 1951 to 1954, inclusive, except as indicated:

	Percent reduction in stand				
Treatment	***May 14**	**May 21**	**May 28**	**June 28**	**Aug. 16**
Mowing	55	50	35		
2,4-D amine 1 lb.	60	58	42	55	15
2,4-D ester 1 lb.	95	95	88	50	20
2,4-D amine 2 lb.				80	
2,4-D ester 2 lb.				90	

* May 14 treatment was not applied in 1951 because of weather conditions.

Good control is indicated for the 2,4-D ester at the earlier dates and with the 2 lb. rate in June. The amine salt did not give much better reduction than the 4 years of mowing in this test. No treatments were made in 1955, and inspection in Sept. 1955 showed many of the remaining plants in the amine plots had set seed while the plants in the mowed plots had not regained much vigor and no seed had been set this year. In the earlier date ester plots, only a few very small shoots remained The July plots showed only moderate reduction in vigor as compared to the check. Recovery from no treatment in 1955 had been enough to allow a fair seed crop.

From the above data, it appears that the ester form of 2,4-D is clearly superior to the amine form for control of buckbrush. In adition, the time of application is of great importance. Early application, while the plant is making very rapid growth and while soil moisture is still usually adequate, seems to be the most effective time. In the Lincoln area, this is about the second week in May. However, the stage of growth and general growing conditions are the things to consider rather than a calendar date.

Conclusion:

Evidence has been presented that methods are available for controlling weeds and brush in pastures. Reduction of weedy species will be accompanied by improvement in the composition with more desirable species increasing under good management practices.

Spraying with 1 to 1½ pounds per acre of 2,4-D in the ester forms will give good control of many weeds and buckbrush in pastures. Buckbrush should be sprayed early in May whereas mid-June is a better date for the majority of the broad-leaved weeds. The spraying program should be planned on a 3-year basis. Additional retreatment may be necessary for some of the more persistent species.

---

[1] Published with the approval of the Director as Paper No. 749 Journal Series, Nebraska Agricultural Experiment Station.

[2] Assoc. Agronomist, Field Crops Research Branch, A.R.S.-U.S.D.A., Nebraska Agricultural Expt. Station, Lincoln, Nebraska.

[3] Now Regional Coordinator, North Central Region, Weed Investigation Section Field Crops Branch, ARS, located at Columbia, Missouri.

XUM

RECOMMENDATIONS
of
RESEARCH COMMITTEE N C W C C

The suggestions and information presented in this report have been prepared by the Research Committee of the North Central Weed Control Conference and represent the combined efforts of a majority of the research workers in the Conference area. The report is reviewed each year and modified to include new developments. This material is presented primarily as background information for persons responsible for making recommendations for the control of weeds and is not intended to be used as definite recommendations for the Conference area as a whole. This limitation is desirable because it is recognized that climate and other factors which affect weed control vary from region to region. **These suggestions therefore do not take the place of state and local recommendations. Specific recommendations should be obtained from experiment station, extension service or other qualified source.**

The use of chemicals suggested in this report, is contingent upon registration by the United States Department of Agriculture and/or establishment of residue tolerances where necessary by the United States Department of Health, Education and Welfare.

Chemicals should be used only as recommended on the label. Persons making recommendations for uses beyond those indicated on the label may be held liable.

The rates of application given for 2,4-D, MCP, 2,4,5-T, TCA and dalapon are on the basis of acid equivalent; the rates for PCP, and DNBP refer to the phenol equivalent and the rates for PMA, IPC, CIPC, CMU, MH, SES, NP and KOCN refer to the active ingredients.

CONTROL OF HERBACEOUS PERENNIAL WEEDS

JOHNSONGRASS (Sorghum halepense L.)

Clean cultivation is usually the most practical method of controlling extensive infestations of Johnsongrass. Heavy pasturing, frequent clipping, or a combination of the two will reduce stands. When practical, a year or two of continuous close defoliation should precede clean cultivation and continue into the first year of clean cultivation until about July 1. The land should then be plowed about 4 to 6 inches deep and thoroughly tilled to bury the tops or to sever them from the underground portions of the plant as frequently as the re-growth reaches a height of about 6 inches. After the first year, tillage should begin in the spring when the Johnsongrass is about 6 inches tall. It should always continue until growth is stopped by cold weather. It requires from 1 to 3 years of clean cultivation to give good control by this method. Johnsongrass seedlings which continue to appear should be destroyed by cultivation or the use of chemicals. With somewhat slower progress, small grain can be produced on the land with plowing and clean tillage applied from harvest time until cool weather stops growth or until time to plant small grain in the fall. Alfalfa is a good competitive crop. It is more effective in controlling Johnsongrass if cut more frequently than normal for hay production.

Chemicals are suggested for treating scattered plants which survive cultural control methods, small patches of Johnsongrass on cultivated land, and for Johnsongrass control on non-cultivated land. The suggested treatments are sodium chlorate, 3 to 5 lb. per sq. rod (480 to 800 lb. per acre); TCA, ⅜ to ⅝ lb. per sq. rod (60 to 100 lb. per acre); on non-crop land only, CMU at ¼ to ½ lb. per sq. rod (40 to 80 lb. per acre); a boron-chlorate mixture containing at least 20% sodium chlorate, 6 to 9 lb. per sq. rod (960 to 1440 lb. per acre); or dalapon, 5/32 to 5/16 lb. per sq. rod (25 to 50 lb. per acre).

CANADA THISTLE (Cirsium arvense L.) and PERENNIAL SOWTHISTLE (Sonchus arvensis L.)

Intensive cultivation followed by winter wheat or rye has proved to be an effective method of controlling Canada and perennial sowthistle. The area should be plowed in the spring (early in dry springs, but when budding in wet springs), and cultivated with a duck-foot field cultivator or one-way disk every three weeks until fall, when the grain crop is seeded. After the crop is harvested, the process is repeated. Two and possibly three years will be required to eliminate these weeds. One year (from spring to freezeup) of intensive cultivation can be used to eliminate a high percentage of the thistles in areas where erosion is not a problem. Three months of intensive cultivation followed by a good crop of alfalfa or perennial grasses will eliminate a high percentage of the thistles in three years. Likewise, a good summer smother crop, such as close drilled soybeans, sudan grass, or millet, when preceded and followed by intensive cultivation, will give good control in two or three years.

2,4-D and MCP are more effective than 2,4,5-T on these thistles. Sowthistle is somewhat more readily controlled than Canada thistle, especially if ester formulations are used. Usually at least two applications of 2,4-D each year over a period of two or more years are necessary to eradicate these weeds. The first application each year should be made at the early bud stage, and one or more treatments made later in the summer and/or early fall. Rates over 1 pound per acre tend to be less effective than is 1 pound. Good control requires spring or early summer treatments followed up by late summer and/or fall treatments. The early treatment should be 2,4-D applied in the crop, but the late treatments may be, in order of effectiveness: (1) cultivate intensively at 3 to 4 week intervals from harvest until freezeup; (2) plow after harvest and spray thistles after they emerge; (3) spray when rosettes are formed and late fall plow; or (4) spray when rosettes are formed. Sodium chlorate gives good control at 3 to 5 pounds per square rod (500 to 800 pounds per acre), though retreatments are usually needed for eradication.

FIELD BINDWEED

Control may be accomplished by repeated cultivations accompanied by growth of a smother crop. Cultivation to cut off all plants about 4 inches below the surface should be repeated 8 to 10 days after each emergence. A duck-foot cultivator is one of the best implements to use. After the plants have been weakened by this treatment a smother crop may be substituted for the cultivation to reduce erosion and yield some return from the land. Wheat, drilled forage sorghum or sudan are effective smother crops. Alternate cultivation and crop should be repeated until the weed is eliminated. Two to four years are required in the Great Plains area.

Applications of 0.75 to 1 lb./A. of 2,4-D will control this weed under most conditions, but 0.50 lb. is often sufficient on cropland. Satisfactory control is obtained by applying 2,4-D at the bud to bloom stage of growth or in late fall. Retreatments in subsequent years are necessary to maintain control. In dry areas, best results are obtained by applying an ester at the pre-bud to bud stage of growth. However, effective control has been obtained on fallow land by cultivating in the spring and spraying after allowing the bindweed to come into the bud or early bloom stage of growth.

Small patches of bindweed may be eliminated by the use of soil sterilants. Sodium Chlorate, at the rate of 5 to 6 lb./sq. rod (800 to 960 lb./A.), or the borate-chlorate mixtures, at the rate of 8 lb./sq. rd. of active ingredient (1280 lb./A.), consistently eliminate this weed. Borax compounds, at the rate of 10 lb./sq. rd. or boron trioxide equivalent (1600 lb./A.), also are often effective in eliminating bindweed. When plenty of soil moisture

XUM

is available, CMU is effective at the rate of 0.5 lb./sq. rd. of active ingredient (80 lb./A.). CMU should be used on non-crop land, only. After use of any of the soil sterilants, spot treatments may be necessary to eliminate scattered remaining plants.

TOADFLAX (Linaria vulgaria Hill)

On arable land extensive infestations of toadflax may be controlled by using a system of intensive tillage of fallow alternated with cropping to grain. One-way disking the stubble in the fall prior to the fallow year is essential to cut off any seedlings or new shoots. Permitting green growth to appear for 5 to 8 days between tillage operations has been as effective as keeping the fallow absolutely black throughout the season. 2,4-D at 2 lbs./A. may be substituted for part of the tillage operations.

Intensive tillage prior to seeding down to brome, crested wheatgrass or creeping red fescue and this followed by repeated spraying of the sod with 2,4-D ester at not less than 2 lbs./A. will effectively reduce the stand and vigor of this weed.

Soil sterilants can be used efficiently on small patches only. CMU at 40 to 60 lbs./A., sodium chlorate, borascu, borate-chlorate compounds and borate-2,4-D compounds at 640 to 1280 lbs./A. will give satisfactory control under most soil climatic conditions in western Canada. Repeat treatment at lighter rates may be necessary to kill surviving plants. Borascu and borate-2,4-D compounds at the lower end of the range of the recommended rates can be used selectively to remove toadflax from grassed areas.

WILD GARLIC (Allium vineale). 2,4-D ester at not less than 3 lbs./A. applied in late March or the first week in April, well before the bulblets appear, had given good control. Repeat applications in the fall and in the following year will be necessary.

FIELD HORSETAIL (Equisetum arvense). Satisfactory top growth control in barley may be obtained by the use of MCP or 2,4-D at 4 oz./A. applied as soon as the horsetail has fully emerged. Selective control of horsetail in grassland may be achieved by the use of borate-2,4-D compounds at 1200 lbs./A.

ORANGE HAWKWEED (Hieracium aurantiacum) and **TANSY (Tanacetum vulgare)** can be readily controlled by spraying with 2,4-D ester at 2 to 3 lbs./A. in the bud flowering stage and repeating the treatment in September. Similar control of buttercup **(Ranunculus acris)** will be obtained by spraying in the flowering stage with 2 lbs./A. of MCP amine.

QUACKGRASS

Cultural methods are probably the most economical form of control on large infestations. Tillage should be at a depth of 2 or 3 inches with a spring-tooth harrow or one-way disk, if a plow is used the sod must be cut up with a heavy disk. The first operation should be about July 1 when drying conditions are good. Succeeding cultivations should be performed about one week after weeds emerge or when the regrowth is 2 or 3 inches long and should be continued until fall freeze-up. A spring-tooth harrow or field cultivator equipped with spring shanks and bull-tongue points (shovels 1 to 2 inches wide) operated at a slightly lower depth for each successive cultivation is the preferred implement. A one-way disk is also effective. It is important to see that the maximum number of rhizomes are brought to the surface where they will be quickly dried by wind and sun. Shallow cultivation in the late fall which exposes the rhizomes to freezing is effective in reducing stand and spring regrowth. Intensive grazing before cultural operations are started aids in reducing the vigor of the plants and enhances control obtained.

Use of chemicals is promising for the control of quackgrass under a number of circumstances. Applications of from 20 to 40 lb./A. of TCA will control quackgrass in humid regions when the application is preceded or followed by a thorough tillage or plowing. Elsewhere from 50 to 75 lb./A. are required. From 80 to 120 lb./A. of TCA are required for control on untilled sod. Dalapon (2,2-dichloropropionic acid) gives results similar to those obtained with TCA. In humid regions it appears to be more effective than TCA when applied to quackgrass with well developed foliage. Soil applications or applications to areas with scanty foliage will require rates similar to those used with TCA. Late summer and fall applications of the heavier rates of TCA or Dalapon are likely to leave a soil residue during the next growing season.

Sodium chlorate may be applied at any time, though probably best in the fall when rainfall is moderate, at 2 to 4 lb./sq. rd. (320 to 640 lb./A.). In sub-humid regions such applications are likely to leave a residue toxic to crop growth during one or two growing seasons. CMU may be used for eradicating quackgrass on non-crop land. Complete or nearly complete kills are obtained by use of from 20 to 40 lb./A. with early spring or late fall treatments being the most effective. Normal growth of crops on the treated areas should not be expected for at least two years.

In humid regions effective control of quackgrass can be obtained by early spring foliage applications of 4 lb./A. of MH followed in 4 to 8 days by plowing. Best results occur on fertile soils or following fertilization of quackgrass with nitrogen to ensure a good shoot growth. Crops may be planted as soon as soil preparation is completed for MH does not leave a toxic residue in the soil.

Dalapon is most effective when applied to quackgrass with a good growth of foliage from 4 to 10 inches tall. Fall treatments of 10 pounds per acre followed in a week or two by plowing or other soil preparation will give good control of quackgrass the following year. Repeated treatments will be necessary for eradication. Crops sown in the spring on treated areas will not be affected following such an application. Dalapon may also be applied to quackgrass leaf growth in the spring. Application of 5 lb./A. when the grass is from 4 to 10 inches tall is most satisfactory. This should be followed in about 2 weeks by plowing or some other form of soil preparation. Some hazard to crops follows the spring application and they should not be planted until 4 weeks have elapsed after the application. Corn, wheat, soybeans and other types of beans are especially sensitive to small quantities of Dalapon remaining in the soil. A single application of 10 pounds of Dalapon per acre in the early spring will give seasonal control in areas that cannot be cultivated but may cause damage to shrubs or trees growing in the area. Two applications of 5 pounds per acre with an interval of 6 weeks will control the growth of quackgrass under mature fruit trees but should not be used under young cherry and peach trees.

HOARY CRESSES (Cardaria spp.)

2,4-D at ½ to 1 lb./A. will control the top growth of hoary cresses in growing crops when applied at the bud stage. Retreatment of fall rosettes with 2,4-D at 1 - 2 lbs./A. will give substantial stand reductions. Such a combination of treatments should give almost complete elimination after 2 - 3 seasons.

Soil sterilants can be used to eliminate small patches of hoary cresses. Sodium chlorate at 4 to 6 lbs./sq. rd. (640 to 960 lb./A.) or boron chlorate mixtures at 6 to 8 pounds of active ingredient per sq. rd. (960 to 1280 lbs./A.) give satisfactory kills. CMU may be used on non-crop land when there is abundant soil moisture at the rate of 40 lbs./A. A fall or early spring application of 2,4-D at 10 lbs./A. may also be used. Soil sterilant chemicals should be applied 6 to 8 feet beyond the existing infestation. Spot treatments following applications of soil sterilants should be used to kill remaining

XUM

plants. Seedlings may be controlled with 2,4-D foliage sprays, by cultivation or by seeding to a close growing grass crop and using supplemental 2,4-D treatments.

BUR RAGWEED (Franseria tomentosa and Franseria discolor)

Bur ragweed may be effectively controlled by an application of 2,4-D ester at the rate of 2 pounds per acre in the pre-bud stage in June.

Sodium chlorate at 4 to 6 pounds per square rod (640 to 960 pounds per acre), soluble boron compounds at 6 to 8 pounds per square rod of boron trioxide (960 to 1280 pounds per acre), the boron-chlorate mixtures at 6 to 8 pounds per sq. rod of active ingredients (960 to 1280 pounds per acre) or granular boron compounds at 8 to 10 pounds per square rod of boron trioxide (1280 to 1600 pounds per acre) can be used to eliminate small patches. A spot treatment the year following application of soil sterilants should be made to kill remaining plants.

RUSSIAN KNAPWEED (Centaurea repens L.)

Two years of intensive cultivation at 2-week intervals with a duck-foot field cultivator will eliminate this weed but is conducive to soil erosion. Winter rye has proved to be a practical competitive crop when used in conjunction with cultivation and 2,4-D. Three crops of rye sprayed in the spring and again in the stubble shortly after harvest with 1 lb./A. of an ester of 2,4-D followed in two weeks by fall plowing and reseeding will give a high percentage of elimination. The fall application of 2,4-D does more to eliminate the weed than the spring application, which serves primarily to prevent seed production. A season of intensive cultivation at 2 week intervals followed by fall seeded bromegrass which is sprayed in the spring, (May) and the early fall (September) with 1½ lb./A. of a 2,4-D ester for 2 or 3 years will eliminate 90% of the weeds. The fall application is more effective for reducing stands than the spring treatment.

2,4-D is effective in controlling Russian knapweed. A rate of 1 to 2 pounds of 2,4-D per acre will prevent seed production when applied before the weed blooms. Slight stand reductions can be obtained by repeated foliage treatments at these rates. Late summer applications tend to be more effective than spring or early summer treatments at these rates. Late summer applications 60 lbs./A. of 2,4-D amine will usually give 75 - 90% elimination of Russian knapweed in the western states of the region, if applied after soil temperature is reduced to 50° F.

Soil sterilants can be used to eliminate small patches of Russian knapweed. Sodium chlorate at a rate of 4 to 6 lbs./sq. rd. (640 to 960 lbs./A.) or borate-chlorate mixtures applied at 7 to 8 lbs./sq. rd. of active ingredient (1120 to 1280 lbs./A.) generally give almost complete elimination when applied during the fall, but are somewhat less effective when applied during the summer. Likewise, straight borax compounds applied at a rate of 10 lbs./sq. rd. of boron trioxide (1600 lbs./A.) or ammonium sulfamate at 4 lbs./sq. rd. (640 lbs./A.) or 5:1 borate - 2,4-D mixtures applied at 3.5 to 4 lbs. active ingredient / sq. rd. (550 to 650 lbs./A.) are often effective on this weed. After treatment with any of the soil sterilants, spot treatments may be necessary to kill remaining scattered plants. Seedlings that emerge after treatment can be killed with 2,4-D.

LEAFY SPURGE (Euphorbia esula L.)

Two years of intensive cultivation at 2-week intervals with a duck-foot field cultivator will eliminate this weed, but is conducive to soil erosion. Intensive cultivation and winter wheat or rye has proved to be a practical method of controlling leafy spurge in areas where these crops are adapted. The land should be duck-foot cultivated 4 inches deep at 2-week intervals from early spring when spurge plants emerge until fall when the crop is seeded. After the crop is harvested the area is cultivated until fall when a second crop is seeded. Several years are generally required to give complete elimination of this weed. Intensive cultivation for one year followed by a crop of sudan grass has given complete elimination of this weed in two years. Before planting the sudan grass, the area should be cultivated from the time that the spurge plants emerge until late June when the sudan grass is seeded with a grain drill. After the sudan is harvested for forage, the area should be cultivated until freeze-up to eradicate any remaining plants.

Intensive cultivation in conjunction with competitive crops and/or 2,4-D has also proved to be an effective method. Early fall plowing (after harvest) followed by intensive cultivation until freeze-up with an application of 1 lb./A. of an ester of 2,4-D when spurge emerges in the spring followed by 4 cultivations applied each time regrowth occurs will often eliminate 99% of the original stand in one year. Likewise, intensive cultivation at 2-week intervals from the time that spurge emerges until freeze-up followed by a spring sown crop of wheat or barley which is sprayed with 0.5 lb./A. of an ester of 2,4-D and followed by intensive cultivation until freeze-up will eliminate leafy spurge if the second year's program is repeated annually over a period of 4 to 5 years. A season of intensive cultivation followed by fall seeded bromegrass which is sprayed in spring and early fall with one lb./A. of an ester of 2,4-D for 2 years will eliminate 99% of the leafy spurge and yield a crop of hay the first year after seeding. If cultivation does not precede the seeding of the perennial grass, 2 applications of 2,4-D a year are needed for 3 or 4 years to eliminate the weed and a crop of hay may not be obtained until the second season after seeding.

2,4-D has been effective in controlling leafy spurge, with the ester forms being most effective. Top growth can be retarded and setting of seed can usually be prevented in small grains with 0.5 lb./A. Several repeat applications of 1 to 2 pounds at pre-bud stage will "thin out" stands of leafy spurge not growing in crop, but 3 or 4 years are required to give appreciable elimination. On rough or stony pastures a proven system is to apply 2 lb./A. of 2,4-D ester at bud stage and retreat whenever regrowth is 4 - 6 inches high followed by a spring application of 50 lb./A. of nitrogen to stimulate grass, which is grazed moderately. The weeds are controlled, but several years are required to give any material decrease in the stand of weeds. Fall applications of 40 lb./A. of 2,4-D amine also will give almost complete elimination in the western states of the region, if applied after soil temperature is below 50° F.

Soil sterilants can be used to eliminate small patches. Borax compounds will generally give almost complete elimination when applied at the rate of 5 to 6 lbs./sq. rd. boron trioxide equivalent (800 - 960 lb./A.) between July 1 and November 1. Likewise, sodium chlorate at 5 lb./sq. rd. (800 lb./A.), ammonium sulfamate at 4 lb./sq. rd. (640 lb./A.), borate-chlorate mixtures at 7 to 8 lb./sq. rd. of active ingredients (1120 - 1280 lb./A.) or 5:1 borate-2,4-D mixtures at 3.5 to 4 lb./sq.rd. (550 to 650 lb./A.) will generally give a high percentage of elimination when applied during the fall; but higher rates are needed during the summer.

Large areas of leafy spurge can be controlled by pasturing with sheep. No harmful effects are produced on the sheep. The degree of control is dependent on the intensity of grazing. Sheep should be turned into the pasture during early spring and allowed to graze the pasture closely. Cattle may be rotated ahead of the sheep if the sheep do not keep the grass down.

XUM

WEED CONTROL IN FIELD CROPS
Spring Sown Grain

While the use of chemicals has added materially in the control of weeds, it is highly important that good cultural practices should be used at all times in small grain production. Proper summerfallow practices performed at the correct time will generally control and eradicate most persistent perennial weeds. The use of chemical herbicides is especially recommended to combat patches of hard to kill weeds by cultivation, such as field bindweed, Canada thistle, and other common weeds.

In spring sown grain, where good cultural practices have been carried out previous to seeding, the use of herbicides is strongly recommended to combat both annual and perennial weeds in the growing crop. Wheat is probably more tolerant to herbicides than barley, oats or flax, the latter being the least tolerant. Canada thistle and sow thistle may be controlled or checked from blooming when sprayed in the crop using 6 to 8 oz./A. MCP ester per acre.

In most crops mustards can be killed by spraying with MCP or 2,4-D in small dosages when weeds are in seedling stage. Some damage to crop in the form of deformed heads and spike sterility may result when sprayed with heavy doses of 2,4-D ester (8 oz./A.) before the grain plants have reached the 5 to 6 leaf stage, and when sprayed less than 10 days prior to heading. Experimental work has shown that small grain crops are more tolerant to MCP formulations and 2,4-D amine than 2,4-D ester.

In general when using herbicides, follow closely instructions on the container. The proper use of herbicides should bring a large measure of weed control but, if not used along with recognized control practices, is unlikely to solve the farmer's weed problem.

Delayed seeding in spring, to assist in combating wild oats, may or may not prove beneficial to crop returns, but assists materially in the control of this weed. At all times when using chemical herbicides remember your neighbor's crop may be just over the fence, and possibly be more susceptible than the crop you are spraying. Do not spray when there is danger from drift, or when winds are blowing over your neighbor's crop if it is more susceptible than the crop being sprayed.

FALL SOWN WHEAT

Winter wheat may be treated with 2,4-D at rates sufficient to control most annual broad-leaved weeds with little injury to the crop. Applications should be made in the spring from full tillering through early jointing, but before the boot stage of growth. Rates of ¼ to ½ lb. of 2,4-D acid equivalent per acre of the ester or up to ¾ lb. of the amine are suggested dosages. Similar applications made in the fall generally result in crop damage and are not recommended. Pre-harvest treatment applied at the milk to hard dough stage should be considered an emergency measure to be used only when weeds threaten to interfere with harvesting operations. An application of one lb. 2,4-D per acre is generally required at this stage even though it may result in some damage to the crop. Weed control at this stage is not often satisfactory. Various broad-leafed weeds and weedy grasses resistant to 2,4-D can be controlled by proper pre-sowing tillage and crop rotations. In seedbed preparation cultivation after plowing is necessary only to control weeds and to prepare an adequate seedbed. Cultivation in excess has no value and will tend to break down soil structure and increase the loss of moisture.

SORGHUM

The use of 2,4-D for weed control in sorghum is recommended only when weeds cannot be controlled by cultivation. Sorghum is most tolerant to 2,4-D when 4 to 12 inches tall. Severe injury may result from treatments applied to plants that are less than three inches tall and also from applications made during the 12-inch through bloom period. Injury from early treatments may result in lodging and a reduced plant population, while brace root malformation is generally a characteristic of 2,4-D applications made during the three- to ten-leaf stage. Late maturity, dwarf plants, and sterility are other expressions of injury attributed to 2,4-D. Forage sorghums appear to be more resistant to 2,4-D than grain types. Varietal differences in susceptibility of grain sorghums is evident. Rates of ¼ to ½ lb./A. of 2,4-D are suggested for use on sorghum. Minimum dosage should be applied during periods when the crop is most susceptible. If more than ½ lb./A. is necessary for weed control some injury may occur.

Spring tillage is important in weed control in sorghum regardless of the tillage given the previous summer, fall or winter. The number of cultivations before planting will depend upon field and weather conditions. In wet seasons conducive to abundant weed growth more frequent tillage is necessary. The loss of moisture by surface drying of cultivated land is more serious during dry springs, but weeds are not so serious under those conditions.

CORN

Weed control in corn is based primarily on cultural practices, including seed bed preparation, establishment of an adequate stand of corn, and timely and effective cultivations. The use of shallow cultivation implements such as the rotary hoe, is highly recommended for the early cultivation operations. Spraying with 2,4-D can be used to reduce the number of cultivations needed and to control some weeds in the row or hill. It should not be expected to replace cultivation because weeds not controlled by 2,4-D will be given an opportunity to develop. Cultivation is needed regardless of weeds on some soil types.

Post-emergence. Spraying should be timed to give complete and early control of the weeds. Rates of ¼ to ½ pound per acre have proven satisfactory; the esters must be used at lower rates than the amines. Lower rates are safer and should be used whenever the danger of corn injury is great, or when very susceptible weeds are to be controlled. Up to 1 pound may be used for resistant weeds with probable injury to the corn. The use of drop nozzles is recommended when large corn is sprayed, except when weeds are as tall as the corn. The spray must strike the tops of the weeds to be most effective. When two nozzles are directed on the row a spray solution equivalent to no more than 0.25 lbs./A. should be used. Some injury to corn may result from 2,4-D spray treatments made during the period from emergence to tasselling. Brittleness and bending or breakage of stalks is the most serious type of injury, and it may result in severe stand losses when followed by a storm or careless cultivation. Several factors influence the degree of injury to corn resulting from 2,4-D treatments. Corn developing under optimum conditions for growth is more susceptible to 2,4-D injury than corn developing under less favorable growth conditions. At the rates of application commonly used for weed control in corn during the period of emergence to tasselling, it is probable that the morphological stage of growth at which 2,4-D treatment is made is less important than the effects of environmental factors on the response of the corn to the 2,4-D except the period extending from two weeks before silking until the silks are dry. Severe reduction in seed set may result from 2,4-D treatments made during this period, regardless of growing conditions. Hybrids and varieties vary in their susceptibility to 2,4-D but differences are not important at rates below ½ pound per acre. Inbred lines vary more widely and single-cross seed fields should not be sprayed except in an emergency, or on inbreds of proven tolerance, and then at minimum rates.

XUM

In areas where annual grasses present a serious weed control problem, the use of selective sprays of the DN type herbicides have shown promise. Some corn injury in the form of leaf burn often results, but yield reductions are generally not serious. An application of 2 - 4 pounds per acre in 20 - 40 gallons of water per acre is suggested. Treatment should be made while corn is in the coleoptile stage, to minimize injury to corn. These low rates of application give no residual effect and can only be expected to kill the seedling grasses present at the time of spraying.

Pre-emergence. In most of the area pre-emergence with 2,4-D will give some control of annual grasses and some tolerant broad-leaved weeds such as purslane, which are not controlled well by post-emergence sprays. On loam soils and those of finer texture, pre-emergence use of 2,4-D is satisfactory is applied before emergence at rates of 1 to 2 pounds per acre. The ester formulations are less hazardous to the corn than amine salt formulations. Dry weather after pre-emergence treatments may make them ineffective and excessive rain creates a hazard to the corn. One pound per acre may not control all weeds but is often more economical, considering cost of materials. The effectiveness of pre-emergence herbicide treatments is greatly increased when the remaining stunted weeds in the hill or row are covered by follow-up cultivations. Higher rates of application are recommended on soils with high organic matter content. Pre-emergence applications are not recommended on sandy soils. An application of 2,4-D at pre-emergence rates, on the soil and bases of the corn stalks only, just after the last cultivation may prevent the emergence of weeds which otherwise might interfere with harvest. Bending of the stalks at the lowest nodes may follow this treatment.

FLAX

Cultural practices—Weeds are generally more of a problem in flax than in small grain, therefore, growers should sow flax on relatively clean land. Early after-harvest tillage of small grain stubble to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall is a recommended method of preparing land for flax the following year except where after-harvest tillage results in serious wind erosion. Preventing weed seed production in corn, soybeans, and other cultivated crops, followed by surface tillage in preparing the seedbed for flax is desirable weed control practice. Delayed sowing of flax to permit spring tillage for wild oat control has been successful in some areas, although the delay is sometimes detrimental to flax. For delayed sowing, early-maturing varieties such as Marine, Sheyenne, or Raja are generally recommended.

Herbicides—Flax should be sprayed with MCP or 2,4-D as soon as there is sufficient emergence of susceptible weeds to make spraying practical. This will usually be when the flax is 2 - 6 in. tall. Spraying may reduce yields of seed and straw unless weed competition is reduced sufficiently to offset injury from spraying. MCP is less likely than 2,4-D to injure flax and is therefore the preferred material. Use 2 to 3 oz./A. of MCP or 2,4-D in amine formulations for susceptible weeds like wild mustard. Use 4 oz. for lambsquarters, red-foot pigweed, stinkweed, cocklebur, marsh elder, and ragweed. For moderately resistant weeds, good kills are generally not obtained, but by using higher rates of application these weeds can be held in check and their seed production largely prevented. For light infestations of moderately resistant weeds, use 4 oz. in amine formulations but for medium to heavy infestations use higher rates. Use 4 to 5 oz. in amine formulations for wild buckwheat or smartweed. Use 5 to 6 oz. MCP amine for Canada and perennial sow thistle. Use 2,4-D ester at 4 - 5 oz. or MCP ester at 5 - 6 oz. for Russian pigweed and Russian thistle. Ester formulations at these rates may seriously damage flax. Do not spray flax with MCP or 2,4-D during the period between bud and the stage where 90% of the bolls have formed.

TCA at 5 lb./A. will kill green foxtail, yellow foxtail, giant foxtail, and barnyard grass in young flax. The flax should be at least 2 in. tall and the weeds less than 2 in. for best results. TCA can be applied in mixture with MCP or 2,4-D to kill susceptible grass weeds and susceptible non-grass weeds with one application, but this mixture should not be applied after early bud stage.

When flax is used as a companion crop to establish alfalfa, red clover, alsike clover, Ladino clover, timothy, meadow fescue, bromegrass, or crested wheatgrass, use MCP or 2,4-D as directed for flax except that alfalfa or clover seedlings should be at least 2 in. tall. Sweet clover seedlings will probably be killed if the flax is sprayed with MCP or 2,4-D. TCA can be used on flax sown with alfalfa or sweet clover, but TCA will probably kill red clover, alsike clover, timothy, meadow fescue, bromegrass or crested wheatgrass.

SOYBEANS

There are several cultural practices that are useful in controlling weeds in soybeans. Delayed planting combined with early seedbed preparation and frequent cultivation to kill weeds until the planting date are successful in reducing the weed hazard. Growing soybeans in cultivated rows will make weed control easier and more certain than in solid seeded beans. The use of shallow cultivation implements such as the rotary hoe is highly recommended for the early cultivation operations.

Chemical weed control in soybeans has not been fully dependable. There are no post-emergence sprays recommended for soybeans but pre-emergence treatments offer possibilities. DNBP at 4 to 8 pounds per acre has given the most consistent results as a pre-emergence herbicide for soybeans. CIPC at 4 to 8 lbs. has also given good results as a pre-emergence treatment. The lighter rates of each chemical are recommended for the lighter type soils. Chemical applications just before bean emergence have given better weed control with less crop damage than applications at planting time. As with all pre-emergence herbicides, the results will vary with weather conditions.

FIELD AND CANNING PEAS

Weed control in peas is usually accomplished by thorough seedbed preparation prior to planting. Annual broad-leaved weeds may be controlled when in the 2- to 4-leaf stage by applying from ¾ to 1 pound per acre of DNBP as an amine salt in approximately 40 gallons of water.

Broad-leaved annual weeds may also be controlled by applying from 2 to 6 ounces per acre of MCP amine or sodium salt to peas between 3 to 7 inches in height. Flower bud development of Canada thistle can be controlled by application of from 4 to 6 ounces of MCP per acre. MCP amine should be applied in 15 to 30 gallons of water per acre, rather than at lower volumes, to reduce injury to the pea crop.

On moist soils or on areas that can be irrigated, pre-planting applications of 4 to 6 pounds IPC per acre may be used to control wild oats. Applications should be made to non-lumpy soil and thoroughly disked-in to a depth of 2 to 3 inches immediately before planting.

FORAGE LEGUMES

Seedling legumes grow slowly and usually are poor competitors with weeds. To prevent the production of weed seeds in preceding crops, the use of intertilled crops and after-harvest tillage are suggested. Mowing weeds in legume seeding, (except sweetclover) has merit

XUM

if done low enough and late enough to kill most of the annual broad-leaved weeds.

Avoid the use of herbicides on seedling legumes unless the crop is seriously threatened by weeds. When weeds are a serious problem, seedling stands of ladino clover, alsike clover, red clover, and lespedeza may be sprayed with the sodium or amine salts of 2,4-D and MCP, at rates of ¼ lb. or less per acre. Sweet clover and alfalfa usually will be injured by either 2,4-D or MCP applications. In the more humid areas of the region, a complete canopy formed by the companion crop and/or weeds will reduce the injury to the legumes.

TCA at 5 to 7 pounds per acre may be used to control many annual grasses in seeding stands of alfalfa, sweetclover, and birdsfoot trefoil. Apply TCA pre-emergence to the weeds or while the weeds are very small. Alsike, red clover, and lespedeza are injured or killed by TCA treatments. Also, it cannot be used when a grass crop such as wheat, oats, or barley is used as a companion crop.

Dalapon may be used at 2 pounds per acre to control annual grasses in seedling stands of alfalfa and birdsfoot trefoil if the forage is not harvested during the treatment year. Apply the Dalapon soon after emergence of the grass seedlings—often one to two weeks after emergence of the legume. Dalapon may be used later in the season if weedy annual grasses become a problem. However, it cannot be used in grasses such as oats, barley, or wheat used as a companion crop.

In **established** legumes, the use of 2,4-D or MCP is often hazardous. These herbicides may be applied in the **dormant** stage of the legume in late fall after killing frosts or in very early spring. Serious yield losses, and often stand losses, may result from spraying other than when the plants are dormant. The dinitro products may be used on established stands of legumes at 1 to 3 lbs./acre. Established stands of alfalfa, sweetclover, and birdsfoot trefoil may be treated with TCA at 5 to 7 pounds per acre, for control of many annual grasses, without permanent injury to the legumes. Ladino clover, alsike, red clover, and lespedeza should not be treated with TCA.

Control of Herbaceous Weeds in Pastures and Meadows

Good management and controlled grazing are of first importance in any attempt at weed control in pasture land.

In very weedy pastures where good perennial grasses are thin, reseeding may be the most important improvement practice. To be successful, a good firm seedbed should be prepared for any reseeding and fertilizer needs should be taken care of at time of seedbed preparation. Protect new seedlings from grazing until established and graze moderately thereafter. Plowing or intensive surface tillage and seeding to adapted grass and legume species where practicable, will usually eliminate many of the perennial pasture weed species.

Spraying with 2,4-D, 2,4-5,-T or a mixture of the two gives better control of more kinds of weeds by a single application than is obtained by a single mowing treatment. Spraying during active growing condition of the weeds is essential for good results. Repeated treatment for two or more years is usually necessary. Increased production of desirable forage and improvement in grass stands following treatment has been reported. In general, these chemicals may be used at rates necessary for weed or brush control without appreciable injury to the grasses. While these chemicals may eliminate some legume species, other native and introduced legume species have a relatively high tolerance to some of the growth regulators.

Seedlings of perennial grasses may be advantageously treated with 2,4-D if the broad-leaved weeds are a problem and if the land is not heavily infested with seeds of the weedy annual grasses. Rates up to ¾ pound per acre may be used after the grass seedlings have reached the 2- to 4-leaf stage of growth. Where weedy annual grasses are the major problem, clipping to prevent seed production may be used successfully.

Mowing has been a recommended practice for controlling many kinds of weeds if done at the right time for 2, 3, or 4 years. In general, mow herbaceous weeds in the early bud to blossom stage.

SUGAR BEETS

Recommended crop rotations and methods of cultivation suited to conditions within the particular sugar beet growing area are the principal means of weed control.

Where annual grasses (except for wild oats, *Avena fatua* are known to be a problem the application of 5 to 7 pounds per acre of TCA just before the emergence of the beets is recommended.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait ten days. TCA at the above rates may then be used to control annual grasses. Some beets will be stunted. This should be considered an **emergency treatment only.**

Selective control of certain broad-leaved weeds may be obtained by the application of sodium chloride (NaCl). From 200 to 300 pounds per acre in 100 to 200 gallons of water, applied when the beets have 2 to 4 true leaves is required. This treatment is not effective on lamb's quarters and purslane.

On moist soil or on areas which can be irrigated, pre-planting applications of from 3 to 6 pounds of IPC per acre may be used to control wild oats. Applications should be made to non-lumpy soil and thoroughly disked in before planting.

Recommendations for the particular beet growing area should be followed for all above methods.

TURF

Proper management which favors the development of turf grasses will aid in weed control. Cut grasses high, apply adequate fertilizer, water properly and reseed bare spots.

Broad-leaved Weeds

In established turf certain perennial weeds can be controlled by applications of 2,4-D made when weeds are in active stage of growth. Periods of active growth in most of the North-Central Region occur in both spring and fall. The amine salt of 2,4-D at a concentration of 0.1 to 0.2 percent acid equivalent and a volume of 1 gallon per 1000 square feet is adequate for most species. Care must be taken to avoid spray drifting onto susceptible ornamentals.

Crabgrass

Some degree of control can be obtained with herbicides. Numerous materials have been used. The following suggestions are given for the use in three materials:

1. KOCN, 3 oz. per 1000 square ft., preferably when crabgrass seedlings are not more than 2 inches in height. Repeated applications at 7 - 10 day intervals may be required.

2. PMA, 0.3 oz. per 1000 sq. ft. as soon as crabgrass seedlings are observed. The application must be repeated at 7 - 10 day intervals until 3 to 5 applications have been made.

3. Disodium methyl arsonate, 4 oz. per 1000 sq. ft. Repeat applications at 7 to 10-day intervals, if necessary. Such treatments may cause severe injury to turf grasses, especially if applied during high temperatures.

XUM

CONTROL OF WEEDS IN HORTICULTURAL CROPS

By wise use of chemicals, it is possible to reduce greatly the cost of weeding many horticultural crops and to save some crops when wet weather makes it impossible to cultivate. However, chemical weed control must not be considered as a substitute for all cultivation but rather should be used to supplement standard cultural practices. There are many herbicidal treatments in addition to those listed here that may be valuable in certain localities. Only those that are of regional interest have been included in these recommendations. For other possible treatments local authorities should be consulted.

All rates of application are based on over-all coverage. It is often more economical to treat only a narrow strip over the row, in which case the application should be reduced accordingly.

VEGETABLE CROPS

Asparagus. The common practice in most areas is to disc asparagus beds in early spring to loosen the soil, destroy weeds and to remove the old ferns. After disking and before spears have emerged, 2,4,-D at the rate of 2 pounds or SES at 4 to 6 pounds per acre may be applied as a pre-emergence spray for the control of broad-leaved weeds. If annual grasses are a problem 5 to 8 pounds of TCA may be added to the 2,4-D or SES spray. CMU at 1 to 2 pounds, and N-1 naphthyl phthalamic acid at 4 to 8 pounds per acre have also been used successfully at this time for the control of both annual grasses and broad-leaved weeds. On muck soil higher rates of application are needed for all materials except TCA.

Following the post-harvest disking, the above herbicides may be used before any spears are showing, but present evidence indicates that it is wise to apply 2,4-D, TCA and CMU only once during any season.

The use of Stoddard solvent at 80 to 100 gallons, DNBP at 1 pound or 2,4-D at 1 pound per acre are recommended for contact pre-emergence treatment to control weeds in asparagus seedbeds.

Beans. In most areas a residual pre-emergence spray to control weeds in the row together with cultivation between the rows has proven quite successful. A smooth, well-prepared seedbed is important where pre-emergence sprays are used.

Six to 9 pounds of DNBP per acre of actual sprayed area will control many annual weeds for a considerable period. The higher rate should be used where sprays are applied very soon after planting. When spraying is delayed until shortly before bean emergence, at which time many weeds may have emerged, the lower rate may be used with equal effectiveness. DNBP should not be applied for beans on light-colored sandy soils.

A pre-emergence spray of CIPC has been used successfully where weeds such as smartweed that are difficult to control with the above material make up a large part of the weed population. Suggested rates per acre are as follows: light-colored sandy soils, 2 to 4 pounds; light-colored loams, 4 to 6 pounds; heavy to dark-colored soils, 6 to 8 pounds. CIPC will control many annual grasses and broad-leaved species but is not effective on lamb's quarters and ragweed. Where many kinds of weeds are present in a field, mixtures of DNBP and CIPC have often given better results than either one alone.

Cabbage, Cauliflower and other vegetables of the genus *Brassica.* When these crops are direct-seeded a pre-emergence spray of 4 to 6 pounds per acre of TCA may be used to control annual grasses.

Spinach. Several kinds of annual grasses and broad-leaved weeds can be controlled in spinach with pre-emergence applications of CIPC. For early spring plantings 2 pounds of CIPC per acre is suggested on sandy soils, 4 pounds on heavier mineral soils and 8 pounds on muck. For fall plantings, 4 pounds is suggested on sandy soils and 6 pounds on heavier mineral soils.

Sweet corn. Pre-emergence treatments of 2,4-D at 1½ to 2 pounds per acre or 6 to 8 pounds of DNBP have given generally good results except on sandy soil. Where 2,4-D is used the low volatile ester formulations are preferred. On muck soil, the rates should be increased by 50%. When sprays of DNBP are delayed until shortly before sweet corn emergence, at which time many weeds have emerged, 4 to 6 pounds may be used with equal effectiveness. These pre-emergence treatments have the advantage over post-emergence applications of 2,4-D of controlling purslane and reducing the stand of annual grasses.

Post-emergence sprays of 2,4-D at ¼ to ½ pound per acre have controlled most broad-leaved weeds without reducing the yield of sweet corn. The lower rate is for ester formulations. Stalk abnormalities and lodging occur to some extent but usually have not been serious. Spraying should be done when the weeds and corn are small. On larger sweet corn the use of drop nozzles will reduce the possibility of injury but thorough weed coverage is essential.

Direct-seeded tomatoes. When a large number of weeds come up before the tomatoes, Stoddard solvent may be applied at 50 gallons per acre about 2 days before the tomatoes start to emerge. Where annual grasses make up most of the weed population, a pre-emergence treatment of TCA at 3 pounds per acre two days before emergence has given good results. A combination of 3 pounds of TCA with 16 pounds of potassium cyanate is especially effective where a mixture of grasses and broad-leaved weeds occur.

Vine Crops. Weeds in cucumbers, muskmelons and watermelons have been controlled successfully with N-1 naphthyl phthalamic acid. It may be applied as a pre-emergence treatment immediately after planting these crops at from 2 to 3 pounds per acre on light sandy soils, 3 to 4 pounds on light-colored loams or 4 to 6 pounds on heavy or dark-colored soils. This compound can also be used as a post-emergence spray just after transplanting or after the field has been freshly cultivated and hoed. In this case the rate of application should not exceed 4 pounds per acre. N-1 naphthyl phthalamic acid should not be applied to extremely early plantings of vine crops when the soil is cold.

Certain varieties of pumpkins and squash are less tolerant to this herbicide than the other vine crops. They should be sprayed only in accordance with local recommendations.

Seedbeds and plantbeds. Weeds can be controlled in seedbeds and plantbeds with steam sterilization or fumigation with methyl bromide.

Waste places adjacent to vegetable fields. Weeds along drainage ditches and fence rows, around buildings, under irrigation lines, and other waste places can be effectively controlled with oils, DNBP, PCP and TCA.

VEGETABLE "ROOT" CROPS

Beets. For annual grasses, a residual pre-emergence spray of 8 to 10 pounds per acre of TCA has provided excellent control. For best results the land should be well prepared by the removal of as many lumps and clods as possible. There appears to be some advantage in the control of grasses and a few small broadleaved weeds if the spray is applied 3 to 4 days after planting.

If the weather makes it impossible to apply the spray before emergence of the crop, it is best to wait 10 days. Ten pounds of TCA may then be used to control grasses only. Some beets will be stunted. This should be considered an **emergency treatment only.**

XUM

Carrots, Celery, Dill, Parsnips, and **Parsley.** Small annual weeds may be controlled on muck and upland soils with applications of Stoddard solvent at the rate of 80 to 100 gallons per acre if the entire area is sprayed. The quantity may be reduced substantially if only a narrow band over the row is treated. The sprays should be applied when most of the first crop of weeds has emerged but before any of them are more than two inches tall.

Maximum effectiveness may be obtained, and in some instances with lower rates, by applying the chemical at night when air movements are down and the relative humidity is high. Early evening applications before the dew has formed may prove most satisfactory in those areas where exceptionally heavy dews may cause excessive runoff of the chemical later at night.

Carrots and parsnips should not be sprayed after the tap root is more than one-fourth inch in diameter or after five or more leaves are present. Stoddard solvent may be applied to celery only in the seedbed.

Onions. For the control of weeds that have emerged before the onions, Stoddard solvent at 60 to 80 gallons per acre, or 3 to 5 per cent sulfuric acid at 100 gallons per acre can be used as pre-emergence sprays. CIPC has given good results when applied just before onion emergence at 4 to 6 pounds on heavy mineral soil and 8 pounds on muck where lamb's quarters and ragweed are not important. It is particularly effective on smartweeds (*Polygonum spp.*) and purslane (*Portulaca oleracea*), giving residual control for 2 to 4 weeks on these species. Pre-emergence sprays with combinations of CIPC and contact weed killers such as Stoddard solvent have controlled a wide variety of weed species.

For the control of weeds in onions in the "loop" stage, post-emergence sprays of 6 to 8 pounds of CIPC or 12 to 16 pounds of potassium cyanate per acre is recommended on muck soil.

For the control of weeds in onions having three leaves or more **basal** applications of 3 to 4 per cent sulphuric acid at 100 gallons per acre, 16 to 20 pounds of potassium cyanate, or 8 pounds of CIPC in 50 to 100 gallons of water per acre is recommended. The CIPC treatment is particularly effective for the residual control of purslane (*Portulaca oleracea*). All such sprays should be applied so as to avoid hitting the tops of the onion plants.

Potatoes. While blind cultivation is generally preferred to control weeds before the emergence of potatoes, in wet weather chemical treatments may be valuable. DNBP at 5 to 10 pounds and sodium PCP at 15 to 30 pounds per acre have given good results when applied 2 to 6 days before emergence. The higher rates are used on muck soil. Where annual grasses are a problem TCA at 8 to 10 pounds per acre may be used as a pre-emergence spray either alone or in combination with one of the above herbicides.

FLOWERS

Gladiolus. Pre-emergence treatments of 2,4-D (ester or salt) at 2 pounds per acre (referring to the area actually sprayed), DNBP at 8 pounds per acre, and sodium 2-4-dichlorophenoxyethyl sulfate (SES) at 3 to 6 pounds per acre will control most annual broadleaved weeds. Where annual grasses are the primary problem TCA, at 10 pounds per acre can be used. If both types of weeds are present a mixture of one pound 2,4-D and 10 pounds TCA may be used.

Post-emergence treatments with 2,4-D (salt) at the rate of 1 pound per acre, when the gladioli are six inches tall or before the leaf blades open, controls most of the weeds in the row. Considerable injury may result if higher concentrations of 2,4-D are used and if the plants are treated in their later stages of growth.

Investigations indicate that SES is less injurious than 2,4-D and can be used pre-emergence at the rate of 3 to 4 pounds per acre and post-emergence at similar rates.

Although cormels grown for size increase are more subject to injury than flowering size corms, SES can be applied at the rate of 3 - 4 pounds per acre before, or immediately after the leaf blades appear.

Chrysanthemums. SES may be used at the rate of from 3 - 4 pounds per acre in beds or in the nursery row 2 - 3 weeks after transplanting.

FRUITS

Brambles. Weeds within the plant row of brambles grown in a hedge row or linear system cannot be controlled by machine cultivation. A deep mulch of sawdust, shavings, ground corn cobs, or straw helps measurably in the control of these weeds but the cost may be prohibitive under certain conditions and moreover, the mulch presents certain hazards. Weeds will grow through these materials in time.

Sodium 2,4-dichlorophenoxyethyl sulfate (SES) is effective as an herbicide for use in raspberries. It can be used at the rate of 3 to 6 lbs. per acre at any season without injury to canes, foliage, new shoots or fruits. To be effective this chemical must be applied before weeds emerge from the soil. SES is effective against both broad-leaved weeds and grasses.

Early spring applications, especially in the northern states, are not as effective as desired, due possibly, to the slow conversion of the chemical to the active form.

This crop is somewhat tolerant of 2,4-D and DNBP (amine.) Basal directed sprays of these chemicals, if carefully applied with low pressure equipment, will not damage the canes and will control many species of weeds. The first application should be made early in the spring before the weeds and new bramble shoots emerge. The second application should be delayed until the new bramble shoots are tall enough to permit spraying without hitting the tips which are easily injured. 2,4-D (salt) can be used at the rate of ½ to ¾ lb./acre with the higher rate for the early application. Do not use the ester form of 2,4-D in raspberries. Do not use 2,4-D during the blooming stage. DNBP (amine) can be used at 2 to 4 lbs. per acre. Use the higher concentration for the early spray and the lower rate for the later sprays when the newly emerged canes are tender. A minimum amount of spray should contact the base of the canes. DNBP is effective only while the grasses and broadleaved weeds are small.

CIPC, 6 pounds per acre, applied in October or November appears promising for the suppression of common chickweed and fall-germinating grasses. Dalapon, 5 pounds per acre, also appears promising as a fall spray.

Grapes. Where weeds beneath the trellis cannot be controlled effectively by the grape hoe they may be controlled by treatment with contact herbicides such as oil emulsions fortified with DNBP or PCP. Use 2 lbs. of DNBP, 15 gallons of aromatic or fuel oil and make up to 100 gallons with water. Four pounds of PCP may be **substituted** for the DNBP in the above mixture. Use a suitable emulsifving agent and make certain that the oil remains emulsified. Apply at the rate of 50 gallons per acre in an 18 inch strip beneath the trellis. Use a low pressure sprayer with a fan type nozzle. Keep the spray off the foliage and do not spray young vines which are not yet protected by a coating of loose bark.

Both CMU, 2 pounds per acre and CIPC, 10 to 14 pounds per acre applied to weed-free soil or small weeds have shown considerable promise for use in mature vineyards. One application per season is usually adequate.

Grapes are extremely sensitive to hormonal type herbicides such as 2,4-D.

Strawberries. In most seasons weeds in newly set strawberry fields can be controlled by mechanical cultivation up until the time that runner plants begin to set. After this time considerable hand labor is required to keep the row free of weeds. Strawberries are somewhat tolerant to hormonal type herbicides and 2,4-D and sodium 2,4-dichlorophenozyethyl sulfate (SES) are the most promising herbicides for use in this crop.

Pre-planting treatments with 2,4-D (amine salt) have shown promise at the rate of 2 to 3 pounds per acre (higher rates for clay soils and soils high in organic matter and lower rates for sandy soils) where the soil is disturbed little in the planting operation. 2,4-D may be used as a selective foliage spray at the rate of 1 lb. per acre during the period from 3 to 4 weeks after setting until late August when fruit bud differentiation begins. Treatment at the time of runner initiation usually causes a marked inhibition of runners.

To be effective against grasses 2,4-D must be applied no later than the germination stage. For the control of over-wintering weeds 2,4-D at the rate of 1½ pounds per acre has given excellent control of susceptible weeds. Application, however, must be delayed until after the period of fruit bud differentiation to prevent fruit deformity.

One pound or less of 2,4-D may be used at the time of mulch removal if over-wintering broad-leaved weeds were not controlled in the late fall. One pound of 2,4-D per acre may be used just before the fruit begins to ripen as an emergency measure if annual broad-leaved weeds threaten to take the field. 2,4-D must not be applied during the blooming period. This material has an important place in weed control the second summer and can be used at the rates of 1½ to 2 pounds per acre immediately after picking. Procedure: mow field; narrow row to desired width; spray.

Sodium, 2,4-dichlorophenoxyethyl sulfate (SES) is an effective herbicide after it has been changed to an active form in the soil by the micro-organisms. Due to the nature of this material it is less injurious than 2,4-D to the strawberry plants but it is effective against weeds only in the germinating seedling stage. This material may be used immediately after setting at the rate of 3 to 6 lbs. per acre but the preferred time of application is 2 to 3 weeks after the plants are set. Excellent weed control for three weeks or longer is usually obtained. Repeat applications may be made during the spring, summer and fall months as needed. Runner production is reduced only slightly at these rates. It appears safe to use during the critical period of fruit bud differentiation. Rates in excess of 2 to 3 pounds can cause considerable injury on light sandy soils, especially in dry, hot seasons.

Fall germinating overwintering weeds can also be controlled by DNBP (amine), 3 pounds per acre, in late fall or winter after the strawberries are **fully dormant.**

Where common chickweed is the principal fall-germinating weed, CIPC, 1½ to 2 pounds per acre, applied in late October or November appears promising.

Herbicides may be applied to the whole field or applied only in a band over the row. Rates of application are based on the area sprayed and the actual amount of chemical applied will be ½ or less of the per acre rate in the case of band applications.

CONTROL OF WEEDS IN WOODY CROP PLANTS, PARTICULARLY FOREST AND ORNAMENTAL NURSERIES AND SHELTERBELTS

Control of Brush on Future Nursery Planting Sites: See recommendations under section "Control of Woody Plants."

Control of Quack Grass and Field Bindweed on Future Nursery Planting Sites After Brush Removal: Application of ½ to 1 pound of 2,4-D per acre in the fall or in the bud to bloom stage are effective for the control of field bindweed. A repeat application may be necessary if satisfactory control is to be achieved.

Quack grass can be controlled by the application of TCA at the rate of 80 - 100 pounds per acre in the fall, to undisturbed sod, and at 25 - 70 pounds when combined with thorough cultivation. In drier areas cultivation prior to chemical application is suggested. Repeat applications and cultivation may be necessary in the event of heavy infestations. In sub-humid regions the residual effect of late summer or fall applications can be expected to extend into the growing season following treatment. Effective suppression may be secured from early spring applications of from 5 - 8 pounds per acre MH when there is a good stand of foliage about 6 - 8" in height. Three to six days after application the quack should be plowed and worked down. Crops subsequently transplanted or sown will not be injured. Dalapon has shown promise for the control of quack grass when applied at the rate of 10 - 15 pounds per acre to good stands of quack foliage 6 - 8 inches in height. If the grass has not been completely eliminated a 5 - 8 pound per acre application may be necessary in late October or early November if the foliage is green. The chemical may also be applied in the spring, to "regrowth," following mowing in the fall. It is not known what the effect will be on nursery stock placed in the field during the growing season immediately following treatment.

Control of Weeds in Seedbeds and Transplant Beds: Weeds can be controlled successfully with steam sterilization, methyl bromide, sodium N-methyl dithiocarbamate dihydrate, and other soil fumigants. For weed types which germinate in the upper soil horizon, granular calcium cyanamide, applied at the rate of from 50 - 75 pounds per 1000 square feet to a warm, moist soil and worked into the upper 2 - 3 inches is also recommended, provided the area is not to be planted immediately. Stoddard solvent or equivalent aromatic oils may be used as contact herbicides for the control of small, broadleaved weeds and annual grasses in coniferous seedling and transplant beds. The rate of application varies from 15 - 75 gallons per acre, depending on the species and the stage of growth of the seedlings at the time of treatment. Repeat applications when seedlings are small is essential to effective weed control.

Established Stock: Considerable hand labor can be eliminated by planting lining-out stock on the square to permit cross cultivation.

For coniferous transplants and deciduous stock in rows, aromatic oils fortified with PCP or DNBP may be used between rows. A low pressure sprayer with a hooded boom should be used to prevent drift. Because of the oil in the mixture, application to the base of the stem should be avoided.

SES is a promising herbicide for use in many species of ornamental plants at specific stages of growth. Most plants which are established in the nursery row, or which have been transferred to the field with a soil ball are unaffected by the application of SES at the rate of 3 - 5 pounds per acre. This chemical is generally applied to weed-free soil both between plants and in the nursery row. In general, the herbicide has not been satisfactorily employed for weed control during the cool temperatures which prevail early in the spring in the North Central Region. The large number of species found in our nurseries has made it impossible to test all for tolerance to SES. Consult your own experiment station for information on the tolerance of the individual species and the proper amount to use on your particular soil type.

CIPC may be used at the rate of 6 pounds per acre in October in newly established apple stool blocks. It may also be applied to mature stool blocks after cutting and leveling in November or for dormant

XUM

season weed control in established nursery stock. A combination spray containing 2 pounds each CIPC and SES per acre as a directed soil application to woody lining-out stock is recommended. Two or three repeat applications during the growing season, preferably after a rain may be necessary for an effective control sequence.

CONTROL OF WOODY PLANTS

Brush on Rangeland and Pastures

The herbicides, 2,4-D, 2,4,5-T, or 2,4,5-trichlorophenoxypropionic acid formulations (low volatile esters preferred), and ammonium sulfamate, will control many of the brush and tree species on land suitable for range and pasture development. However, their use should be accompanied by a management program which will favor prompt recovery of the desirable grasses and native legumes and thus reduce sprout regrowth.

The methods commonly used to apply the above herbicides are foliage sprays, and basal bark or cut surface treatments on stumps, in frills, or in cups. The best time to apply foliage sprays on most woody plants is at full leaf and during the three to four week period thereafter, providing soil moisture conditions are sufficient for active growth prior to time of spraying. The rates of application given for 2,4-D, 2,4,5-T, and 2,4,5-trichlorophenoxypropionic acid formulations refer to acid equivalent.

Foliage Sprays (ground equipment)—Woody plants sensitive to either 2,4-D, 2,4,5-T or 2,4,5-trichlorophenoxypropionic acid ester formulations may be controlled with a solution consisting of at least 3 pounds of the chemical in 100 gallons of water. The herbicide, mixed with sufficient diesel oil to make 10 gallons and emulsified in 90 gallons of water, is sometimes more effective for late season application.

Ammonium sulfamate, 95 percent active, in a concentration of at least ¾ pound in 1 gallon of water with the addition of a spreader-sticker is effective on mixed brush.

Foliage Sprays (aerial equipment)—The post oak, blackjack, and other associated brush and small trees may be successfully controlled with annual applications of herbicides for two consecutive years. In some instances, an application the third year may be desirable. If either the 2,4,5-T or 2,4,5-trichlorophenoxypropionic acid formulation is used, the initial applications should be made at the rate of 2 pounds per acre, followed by retreatments of 1 to 2 pounds. Either herbicide may be satisfactorily applied in a spray solution at 5 gallons per acre. This spray may consist of the chemical mixed with sufficient diesel oil to make 1 gallon and emulsified in 4 gallons of water, or the chemical may be mixed with the oil alone in an amount necessary to make 5 gallons. If an equal mixture of 2,4-D and 2,4,5-T is used, the first application should be with 3 pounds and the following treatments with 2 pounds in the same quantity of spray solution per acre as for the 2,4,5-T.

Studies on the control of shinnery oak indicate that effective results may be obtained with 2,4-D ester at 1 pound in 3 to 5 gallons of diesel oil or in an emulsion of 1 gallon of diesel oil and 2 to 4 gallons of water per acre. This application must be made for two consecutive years with a low volatile ester to obtain effective control.

Sand sage is controlled with 1 pound of 2,4-D ester in 3 gallons of an oil-in-water emulsion or 3 gallons of diesel oil per acre. The best period for spraying sand sage is during May or early June, when the plants have 6 to 8 inches of new growth and are developing rapidly.

Buckbrush generally may be controlled by repeated applications of 1 to 2 pounds of 2,4-D ester per acre. The herbicide may be applied in 3 gallons of an oil-in-water emulsion or the same quantity of diesel oil per acre. This plant may also be effectively treated with ground equipment, using 2 pounds of the chemical in 100 gallons of water as a wetting spray. The effectiveness of control of this plant will vary with the difference in species, variety, and location.

For aerial spraying, oil-in-water emulsions in proportions such as 1:4 give larger droplet size than commonly used oils and thus reduce drift hazard.

Basal Bark Treatments—Basal bark and ground line treatments are good control measures on trees less than 6 inches in diameter. Concentrations ranging from 8 to 16 pounds of the low volatile 2,4,5-T ester in 100 gallons of diesel fuel are recommended for most species. However, cottonwood and willow may be controlled with the same quantity of 2,4-D ester. The basal bark treatment may be advantageously made between December 15 and March 15.

Stump, Frill and Cup Treatments—Sprouting on freshly cut stubs and stumps may be prevented by thoroughly wetting the tops and sides of the stumps, as well as any exposed roots, with a solution of 8 to 16 pounds of 2,4,5-T ester in 100 gallons of diesel oil. This treatment is also effective if applied in "frills." These "frills" consist of overlapping downward axe strokes made completely around the trees near the ground line. The injured area must be thoroughly wetted. The same solution may be successfully used in "cups" made with special tools. Regrowth on stumps may also be prevented by application of ammonium sulfamate (95 percent concentration in the crystal form) or in a concentrated water solution (3 to 5 pounds per gallon).

Soil Applications—The 3-(p-chlorophenyl)-1, 1-dimethylurea (Karmex) has satisfactorily killed oak and most associated woody species. This chemical was most effective when applied at rates of ⅛ to ¼ pound (approximately 7½ to 15 pounds per acre) of 80 percent active powder per gallon of water, with the spray being applied on the surface of the soil around each plant. It appears to be equally effective during both dormant and growing seasons. Karmex, in soil applications at 7½ pounds per acre, has not materially affected the growth of established grasses, such as little bluestem, big bluestem, Indian, switch, and sand love.

Brush on Rights-of-way

Effective chemicals for the control of woody plants on rights-of-way are 2,4-D, 2,4,5-T, and ammonium sulfamate. Mixtures of 2,4-D and 2,4,5-T are useful when mixed stands of woody plants are to be controlled. Amizol and 2,4,5-T propionic may also be used successfully on susceptible woody species.

Foliage Sprays. Woody plants sensitive to 2,4-D and 2,4,5-T should be treated using a wetting spray containing at least 3 pounds acid equivalent 2,4-D or 2,4,5-T per hundred gallons of water. Brush killers containing 2,4-D and 2,4,5-T are suggested where mixed species are encountered. Low volatile esters may be advantageous, especially in areas where volatility may be a problem. Where 2,4,5-T acetic is recommended as a foliage spray on oaks, 2,4,5-T propionic has been equivalent in most instances and superior in some cases. Ammonium sulfamate at a concentration of at least ¾ pound per gallon of water is effective as a foliage spray on mixed brush. The addition of a spreader-sticker to ammonium sulfamate is advisable. Amizol has been effective on such species as: white ash, poison ivy, wild black cherry, and various oaks at the rate of 6 pounds per 100 gallons of water. Aerial spraying on utility rights-of-way is still in the development stage.

Basal Sprays (dormant and active growth period). Basal sprays of 2,4-D and 2,4,5-T properly applied are usually more effective on the more resistant species than are foliage sprays. Smaller trees, usually under 6 inches

in diameter are most responsive to this method. Applications of 2,4,5-T or mixtures of 2,4-D and 2,4,5-T at rates of 8 to 16 pounds per hundred gallons of oil have proved effective. It is most important to spray the entire basal area of all stems to the point of run-off. Thorough coverage and high volume of spray with this method are most important.

Stump Treatment. In areas recently cut, as in the case of new rights-of-way or where dead standing trees are objectionable as along highways, the cut plants may be effectively treated by using 2,4,5-T or mixtures of 2,4-D and 2,4,5-T at rates of 8 and 16 pounds of acid equivalent per hundred gallons of oil. The material should be applied to the stump so as to completely wet the top and sides of the stump to ground level. All exposed roots should be sprayed. Sufficient volume is most important with this method. Ammonium sulfamate applied as crystals or as a concentrated water solution (4 to 6 pounds per gallon) is effective in preventing sprouting of stumps.

Brush in Forests and Plantings

Chemicals may be useful in several ways in connection with controlling undesirable woody plants on forest, plantation, and woodland areas. In many of these applications a goal of temporary control rather than permanent eradication of the woody weeds may be adequate in obtaining the desired objectives. Foliage sprays, cut surface and basal applications are all useful under certain conditions.

For purposes of freeing coniferous regeneration from brush competition, foliage sprays containing two pounds of ester formulations of 2,4-D or 2,4,5-T, per hundred gallons of spray are recommended. Where the brush consists of hazel, willows or alder, 2,4-D is adequate. For the control of blackberries, raspberries, cherry, thornapple, ash, osage-orange, basswood and maple, 2,4,5-T is more effective. For mixed brush populations, mixtures of 2,4-D and 2,4,5-T are recommended. Foliage applications should be made after the leaves have attained full size and before their activity has been reduced in late summer. Such applications, properly made, will usually be effective in reducing competition to coniferous seedlings for 3 - 5 years. Where control for a longer period is necessary, repeat sprayings are recommended.

Where brush control is necessary preliminary to the planting of trees for forest plantations, foliage treatments using 2,4-D, 2,4,5-T, or ammonium sulfamate can be used. If natural regeneration of conifers are present on the area, 2,4-D or 2,4,5-T should be used exclusively to avoid killing the conifers.

Chemical treatment can be useful in releasing established plantations from overhead competition and in eliminating poorly formed individuals or inferior species from sapling or pole-sized forest stands. For this purpose cut surface treatments in frills or cups as well as basal applications are recommended. Esters of 2,4,5-T in oil solutions at concentrations of 8 to 16 pounds of acid per hundred gallons of oil are recommended for both cut surface and basal types of application. Ammonium sulfamate as a dry salt or as a concentrated water solution (4 to 6 pounds per gallon of water) can be effectively applied to cut surfaces of stumps, frills or cups to prevent resprouting of most species of woody plants. The addition of a sticker or spreader to such water solutions may be necessary.

In some situations aerial sprays have been found to be a cheap and relatively effective method for releasing conifers from an undesirable overstory or competition from brush. Rates of from 1 to 3 pounds per acre of 2,4-D or 2,4,5-T acids or their mixtures in 2 to 5 gallons of oil or oil-water emulsions have been found to be successful in some cases in controlling aspen, alder, oak (bur, northern red and northern pin oaks) and paper birch.

In general, spraying in desirable stands of conifers should be confined to the last half of the growing season to avoid damaging the succulent new growth.

Alternate Hosts

Barberry (*Berberis spp.*,) the alternate hosts of stem rusts of wheat, oats, barley, and rye. European barberry (*B. vulgaris*) can be killed by common salt liberally applied around the base of the plant, but ammonium sulfamate applied to the surface of cane stubs cut at the ground line or basal sprays of MCP ester or a combination of 2,4-D and 2,4,5-T esters (plus PCP) at 14 pounds ahg oil solution also are effective and easier to apply. Also, ammonium sulfamate (6 lbs. per gallon of water) sprayed on to freshly cut stubs has proved effective. Colorado barberry (*B. fendleri*) may be killed also with 2,4-D ester in foliage and dormant stages with 1.6 ahg water emulsion and 10 - 14 pounds ahg oil solution, respectively, as well as with sodium chlorate ("Atlacide"). Allegheny barberry is killed in both the foliage and dormant stages by 2,4,5-T ester at 12-14 pounds ahg oil solution or a combination of 2,4-D and 2,4,5-T esters plus PCP.

Currants and **gooseberries** (*Ribes* spp.), the alternate hosts of white pine blister rust. Either basal treatments or cut surface applications with 2,4,5-T esters or a combination of 2,4-D and 2,4,5-T esters at 8 to 14 pounds ahg oil solution kill most upland ribes, namely: *R. cynosbati*, *R. missouriense*, *R. hirtellum*, and *R. americanum*. The latter species also can be killed in both the foliage and dormant stages with 2,4-D ester at 0.75 to 1.6 pounds ahg water emulsion and 8 to 14 pounds ahg oil solution, respectively. Prostrate swamp species are usually more difficult to eradicate. Overall sprays using oil solutions of 2,4,5-T are effective. In Ribes control, careful application is essential.

Buckthorn (*Rhamnus* spp.) the alternate host of crown rust of oats. Eradication of buckthorn within a radius of one half mile of oat fields by mechanical uprooting (digging or pulling), spraying of freshly cut stumps or the bases of trunks with a mixture of 2,4-D and 2,4,5-T in oil (12 - 16 lbs. ahg), or applying ammonium sulfamate to freshly cut stumps is recommended.

Red Cedar (*Juniperus virginiana*) alternate host of apple, pear, and quince rusts. These trees may be killed with common salt (sodium chloride), sodium chlorate, and possibly other soil sterilants applied at the ground line. Foliage wetting sprays of ¾ pounds ammonium sulfamate per gallon of water or a mixture of 2,4-D and 2,4,5-T ester (5 ahg of water) are also effective.

SHRUBS POISONOUS TO TOUCH

Poison Ivy (*Toxicodendron or Rhus spp.*) A thorough foliage spray of 2,4,5-T ester or a combination of 2,4-D and 2,4,5-T esters at 2 pounds ahg water emulsion is recommended. A dormant spray of 2,4,5-T at 12 pounds ahg in oil may be used. Ammonium sulfamate (¾ lbs. per gallon of water), sodium chlorate (5 lb. per sq. rd.) or borax formulations (15 lbs. per sq. rd.) also have proved effective.

Poison Sumac (*Rhus vernix*). Due to the height of this shrub and danger of skin poisoning, treatment with either a growth regulator, ammonium sulfamate or a soil sterilant type of herbicide in the dormant rather than the foliage stage is recommended.

CHEMICAL DRYING AND PRE-HARVEST WEED CONTROL

Chemical desiccation of crops and weeds may facilitate harvesting operations, and under many conditions, improve seed quality and increase yields. Since contact-type chemicals are used there is no translocation to roots which could reduce stands of perennial crops. Satisfactory results with these materials are dependent upon uniform coverage, therefore spray volumes are an

XUM

important part of the suggestions. Oil or oil-water emulsion carriers improve wetting and tissue penetration when oil soluble chemicals are used. Water soluble materials should contain wetting agents or have wetting agents added to the spray solution. Spraying by airplane will avoid wheel damage caused by ground sprayers. Five gallons per acre is suggested as a minimum volume for aerial application.

Alfalfa and Alsike Clover. Treatments may be applied after most of the seed pods have turned brown. DNBP at 1.25 to 1.87 lbs. per acre or PCP at 4 to 6 lbs. per acre applied in 5 to 10 gallons of diesel fuel per acre usually allows combining in 2 to 4 days. The rate of application and volume of carrier should be varied depending upon the density of the foliage. On heavy growth, a retreatment may be needed using ½ the initial rate 1 to 2 days after the first application. The higher rates are needed during late fall when temperatures are lower. In the northern portion of the Conference area, Endothal at 1 to 1¼ lbs. in 20 gallons of water per acre has been equal or superior to DNBP and PCP.

Sweet Clover. Apply chemical desiccants when ½ the seed pods have turned brown. Shattering is a serious problem in sweet clover seed production and attention should be given to weather forecasts. Harvest as soon as moisture conditions permit. Use DNBP at 1.25 to 1.87 lbs. per acre or PCP at 3 to 4 lbs. per acre in 5 to 10 gallons of diesel fuel. Since sweet clover harvest generally occurs in July when temperatures are high, the lower range of rates given will often be suitable. Endothal may be used as for alfalfa.

Red clover. Apply chemicals when most of the heads are brown and the seed is showing the typical red to purple coloration. Use the chemicals and rates as suggested for sweet clover.

Flax. DNBP at 1.25 to 1.87 lbs. applied in 5 to 10 gallons of diesel fuel per acre or Endothal at 1.25 lbs. in 20 gallons of water per acre can be used.

Soybeans. Green weed growth at harvest time may be dried using DNBP at 1.25 to 1.87 lbs. per acre, or PCP at 3 to 6 lbs. per acre in 5 to 10 gallons of diesel fuel. Treatment should not be applied until most of the pods have turned brown, otherwise bean quality and yield may be affected.

Dry edible field beans. Treatments should be applied after pods are dry and beans have hardened to avoid yield reductions. Endothal at 1 to 2 pounds per acre, sodium chlorate - sodium pentaborate mixtures at 15 to 20 pounds per acre or magnesium chlorate at 2.5 to 5 pounds per acre in 5 to 10 gallons of water applied by airplane or 20 to 25 gallons of water applied by ground sprayer may be used.

Corn. Results have been variable and more work is necessary before recommendations can be given.

MECHANICAL CONSIDERATIONS

Mechanical considerations in a comprehensive program of weed control include the proper use of seed cleaning, tillage, chemical application and harvesting equipment. No one machine or operation in the above group will give satisfactory weed control when used exclusively without regard for the others.

Seed cleaning. It is important that all seed used be free of weed seed. If no weed seed is planted, there will be less work for the tillage and chemical practices which follow and new weed species will not be introduced. Most seed separation problems can be solved by taking advantage of differences in physical characteristics of the seeds. A knowledge of the basic physical property involved is essential if the operator is to make proper use of cleaning and separating equipment. Some of the common methods of separation and the physical differences which are the basis of their operation are as follows: fan and screen method—size, weight, and shape; indented disc and cylinders—length; gravity table—weight; gravity spiral separator—shape; fabric covered rolls—surface texture. In addition to these, if a special cleaning problem exists, many seed firms have specialized equipment to do the job. Whether the seed is cleaned in the home mill or on a custom basis, the cleaned seed should be carefully checked to see that all the weed seed has been removed.

Tillage equipment. Prior to planting most tillage operations accomplish two things; first, the soil is tilled to put it in a physical condition that will be conducive to maximum plant growth; secondly, and of equal importance, tillage operations are performed to give maximum control of weeds. After the crop has been planted the major reason for most tillage is to control weeds. Timeliness, speed, and proper tool adjustment are of vital importance for effective weed control in all tillage operations. All three variables should be given careful consideration in connection with soil type, conditions and crop.

Adjustments are especially important in the use of the cultivator. The shovel type, spacing, and arrangement should be adjusted to give as much weed control as possible within the crop row and yet avoid injury to the tops or pruning of the roots.

Proper timing and speed of operation are very essential for the effective use of the rotary hoe. This implement can best aid in controlling shallow germinating annual weeds in corn and soybeans only if used when the weeds are in the small seedling (white) stage.

Sprayers. In buying a farm weed sprayer, careful consideration should be given to its service and possible repair. For this reason reputable dealers and manufacturers capable of furnishing service and parts are the best source of equipment.

In the selection of a weed sprayer, consideration should be given to other operations likely to require use of a sprayer around the farm. Of special importance is the choice of the pump and the sprayer mounting.

Equipment should be constructed of materials which are resistant to corrosion by the common herbicides. Stainless steel and polyester resins reinforced with fiberglass appear to be the most resistant. Aluminum, brass, and galvanized iron are resistant but in some cases may require special flushing or other precautionary measures. Examples of such instances are the use of aluminum with TCA and brass with ammate. Materials, coatings, hose and gasket material which are not affected by the oils and solvents used with these herbicides should be used. Natural rubber has poor resistance to many petroleum derivatives. Some coating material may provide good corrosion resistance but such resistance is greatly reduced by scratches or breaks in the coating.

Some of the desirable features of a serviceable weed sprayer are as follows:

Tank: The tank should be strong enough to withstand the pressures of the fluid inside and of a size which can be easily maneuvered through the field. The tank size should also be considered on the basis of the amount of spray to be applied per acre. Provisions should be included for easy and complete draining. An opening should be provided which will allow for cleaning the inside when necessary. It is important to have agitation within the tank either by mechanical means or by sufficient by-pass from the discharge line.

Suction strainer. The strainer should be fine enough and of sufficient strength to remove as much foreign material as possible from the solution but of a size that will not throttle the suction of the pump. Inasmuch as this requires a compromise, special emphasis should be put on care in filling the tank. The strainer should be easily removable for cleaning.

Pump. The pump should be of sufficient capacity and quality to maintain adequate working pressures and flow to meet the conditions set by the spraying opera-

XUM

tion. It can be expected that most pumps will lose a part of their efficiency through normal use. The choice of capacity of power take-off operated pumps should allow for their possible use on those tractors which will have a reduced p.t.o. speed under many spraying conditions.

Regulating valve and pressure gauge. These two items should be within easy reach and sight of the operator. The marked increments of the gauge should be such that pressures can be judged accurately over the full range of spraying pressures contemplated.

Boom. Booms should be suitably hinged to reduce breakage and to permit convenient transportation. They should be of sufficient size to prevent a significant pressure drop at the end nozzles and have removable plugs in the ends to facilitate cleaning. In view of the wide range of recommended spray application rates, special care and attention should be given to the selection and performance of the nozzles. They should be uniform in output and in the spray pattern which each produces.

Other features essential to a good sprayer are a quick acting shutoff valve, line filter between the pump and boom, individual filters at each nozzle and some device for measuring the fluid in the tank.

Calibration. Even distribution is the most important characteristic of a good sprayer. Each nozzle and each square foot of area must be checked for even pattern and consistently even spraying. The sprayer output should be calibrated to each particular spraying operation. The best method of calibration is the making of initial adjustments to suit the machine and job requirements and then making a trial run to determine the actual output of the machine. The herbicide should then be mixed accordingly. The calibration should be checked frequently during the operation to check for such things as nozzle orifice wear. This is especially important when abrasive solutions are used.

A speedometer on the tractor or sprayer can be very helpful for quickly detecting any change in speed which will affect the calibration.

Maintenance. A strict cleaning program should be followed after each use of the sprayer. This should include not only flushing the tank, pump, boom, and nozzles, but also cleaning the exterior of the equipment. When the sprayer is prepared for winter storage, all bare metal parts should be coated with oil and the hoses should be disconnected. Procedure for preparing the pump for storage should be based on the specifications and suggestions of the manufacturer of the specific pump. This should include, in most cases, flushing with a suitable oil or preservative and removing the drain plugs. The nozzles should be disassembled, cleaned and kept in a container of oil.

Broadcast nozzles. The broadcast boomless type nozzle may prove very useful for spraying roadsides, fencerows, brush pastures, and other areas for which boom type sprayers prove awkward, and for spraying field crops when there is considerable difference between the tolerance of the crop and that of the major weeds to the chemical used. The swath width recommended by the manufacturer must be followed closely. Most uniform results can generally be obtained at 30 psi pressure in still air (less than 4-7 mph wind). Double coverage by overlapping half a swath will enable the operator to control his swath width better and will give more uniform coverage. If there is any breeze, the spraying should be done with the tractor traveling cross-wind and overlapping one-half the swath width. Calibration is just as important as with conventional sprayers, and should be based on the actual effective swath width.

Harvesting equipment. As an aid in preventing the spreading of weed seed, it is important that a strict cleaning program be set up and adhered to before moving the machine from the field. Each machine should be inspected to determine the places (flat areas, corners, and depressions) where weed seed is prone to collect during normal operation. The removing of dirt and weed seed from such places by compressed air, brushes, or other special equipment should be included in the cleaning process.

AERIAL SPRAYING

Aerial applications of herbicides are economically advantageous and often more effective than other methods under many conditions. Factors to be considered in determining these advantages are: size of area to be sprayed, time available for treating a given area, inaccessibility of the area to other equipment, suitable weather conditions, proximity of other crops which may be damaged by drift, comparative results and costs of aerial applications as against results and costs of other methods.

The most advantageous use of aerial spraying at present is for brush control (mesquite, sagebrush, oak brush and others), for weed control in small grains, pasture, range and other large areas and for pre-harvest defoliation and desiccation.

Even distribution is esential in all herbicide applicatons with a minimum of drift. Therefore, the swath width should be limited to the wingspan if possible or at most should be no more than 125% of the wingspan. The altitude should be as close to the foliage as safety of the pilot and equipment will permit (boom 4 to 5 feet above foliage on flat terrain and even growth; more clearance as necessary on uneven growth and terrain.) The plane should be operated crosswind in order to maintain constant ground speed; but where it is necessary to fly parallel to the wind, flights can be made both up-wind and down-wind providing the pilot can control his airspeed so that ground speed will be constant; otherwise they should be made up-wind only.

If aerial spraying of 2,4-D or brushkillers is recommended in areas where susceptible crops are grown, only low volatile materials should be employed.

Spraying should be done when the wind is constant in direction and as low in velocity as possible.

Drift injury to near-by crops represents one of the greatest problems of aerial applications. Large droplets minimize probability of drift, therefore, nozzles with large orifices should be used at low spray pressure. When it is necessary to increase the rate of spray application, it generally should be accomplished by increasing the number of nozzles, orifice size or other means rather than by increasing the spray pressure. Nozzles should be directed downward and to the rear. Each nozzle should be equipped with a positive shut-off. Light oil diluents break up in finer droplets than water because of lower surface tension, therefore, water or emulsions should be considered where drift presents a hazard.

The following wind velocities are suggested as possible maximums for these representative conditions but the operator's judgment and local conditions such as the proximity of susceptible crops will be the final determining factor:

2,4-D in mixed farming area at 1-2 gal/acre	wind velocity	5 mph
2,4-D in mixed farming area at 5 gal/acre	wind velocity	7 mph
2,4-D in range country at 1-2 gal/acre	wind velocity	7-10 mph
Chemical desiccants anywhere at at 5-8 gal/acre	wind velocity	8-10 mph

Many chemicals settle out of solution or emulsion when allowed to stand. Each plane load should be mixed just prior to take-off or the spray solution in an auxiliary tank should be thoroughly agitated just before each plane load is removed from it. It is desirable that each plane be equipped to provide agitation in the tank either as return flow or by use of a positive agitator.

It is recommended that all owner-operators and pilots be familiar with the character of the chemical

XUM

being used. Owner-operators should exercise close control over the operation of their planes. In the interests of safe operation, each plane should be equipped with all of the safety equipment (crash helmets, shoulder harness, masks, emergency dump valves, wire cutters on the landing gear, etc.) which is available. There is no substitute for good maintenance of the airplane and equipment. The pilot should make a preliminary survey to familiarize himself with potential hazards and obstructions in and around the area over which he is to fly.

The following are considered desirable features of aerial spray equipment:

Tank: The spray tank should be of light weight material. Fiberglas reinforced plastics, aluminum, and stainless steel are preferred for corrosion resistance. Metal tanks which leak or crack at the seam may often be repaired by lining them with fiberglas reinforced plastic. The tank should have a large filler opening to allow for easy cleaning and filling and should be adequately vented to allow for maintaining constant flow. If the tank is large in fore and aft dimensions, baffles should be installed to prevent surging.

Pumps: Positive displacement pumps of the gear type produce excessive pressures and require a relief valve in the pressure line to prevent damage to the plumbing system. Centrifugal pumps in general do not produce excessive line pressures and do not require a relief valve for that purpose, however, such valves are advisable for maintaining constant spraying pressures and to maintain agitation in the supply tank. Pumps driven by external fans should be equipped with a brake assembly while direct engine drives require a clutch.

Booms: The boom should be large enough to prevent a significant pressure drop at the end nozzles and the ends should be fitted with caps for cleaning. Round booms produce more drag than streamlined ones but they are easier to clean. The boom should have fewer nozzles in the 3 to 4-foot space left of center and more nozzles to the right of center to overcome the spray displacement caused by the propeller slip stream. If nozzles are added to increase volume, they should be located in specific positions in a compensated arrangement to give optimum pattern rather than being placed at random. To minimize the effect of the wing tip vortex, no nozzle should be placed within 5 feet of the wing tip. On high wing monoplanes, lowering the outer ends of the booms so there is approximately 3 feet between the boom and lower wing surfaces aids materially in reducing wing tip swirl.

RECOMMENDATIONS OF THE COMMITTEE ON TERMINOLOGY

The committee recommends the use of the terms, definitions, and abbreviations listed in this report in the preparation of abstracts, reports, and articles that have to do with weed control. The use of the recommended forms, definitions, and so forth, is especially desirable in the preparation of short reports in order to conserve space and to make for easier interpretation of results by project leaders and readers in general.

Trade Names and Code Numbers usually should not be used. The Research Committee has ruled that reports on materials by code number or trade name only shall not be used in preparing summaries. Some highly complex organic herbicides have been introduced under trade names. As long as these products are made by only one company, the trade-marked names (always capitalized) may be used in the body of an article or abstract. The first time such a product is mentioned in a research report, the full chemical name should be given, followed by the trade name in parentheses.

Chemical Names and Designations. Chemical symbols should not be combined with alphabetical abbreviations in designating compounds, for instance, the sodium salt of TCA should not be state as NaTCA. In the list which follows, the chemical name is given in (a) followed in (b) by common names of basic compounds (c) common derivatives of basic compound.

Rates and concentrations for materials listed in items 1, 2, 3, 4 and 5 should be stated as the **acid equivalent.**

1. (a) 2,4-dichlorophenoxyacetic acid
   (b) 2,4-D
   (c) 2,4-D, salt (indicate which)
   2,4-D, ester (indicate which)
2. (a) 2,4,5-trichlorophenoxyacetic acid
   (b) 2,4,5-T
   (c) 2,4,5-T, salt (indicate which)
   2,4,5-T ester (indicate which)
3. (a) 2-methyl-4-chlorophenoxyacetic acid
   (b) MCP
   (c) MCP, salt (state which)
   MCP, ester (state which)
4. (a) trichloroacetic acid
   (b) TCA
   (c) TCA, salt (state which)
5. (a) N-1-naphthyl phthalamic acid
   (b) NP
   (c) NP, salt (state which)

   Rates and concentrations for materials listed in items 6, 7, 8 and 9 should be stated as the **phenol equivalent.**
6. (a) pentachlorophenol
   (b) PCP
   (c) PCP, sodium salt (rates have usually been stated in terms of the salt)
7. (a) 4,6-dinitro-o-cresol
   (b) DNC
   (c) DNC, salt (state which)
8. (a) 4,6-dinitro-o-sec-butylphenol
   (b) DNBP
   (c) DNBP, salt (state which)
9. (a) 4,6-dinitro-o-sec-amylphenol
   (b) DNAP
   (c) DNAP, salt (state which)

   Rates and concentrations for all the following materials should be stated as pounds or ounces of active ingredient.
10. (a) phenyl mercuric acetate
    (b) PMA
11. (a) isopropyl-N-phenylcarbamate
    (b) IPC
12. (a) isopropyl-N-(3-chlorophenyl) carbamate
    (b) CIPC
13. (a) 3-p-chlorophenyl-1-1-dimethylurea
    (b) CMU
14. (a) 3,6-endoxohexahydrophthallic acid
    (b) endothal
15. (a) sodium 2,4-dichlorophenoxyethyl sulfate
    (b) SES
16. (a) potassium cyanate
    (b) KOCN
17. (a) Maleic hydrazide
    (b) MH

    All other compounds should be listed by their full chemical names.

DEFINITIONS

1. **Pre-emergence** applications are those made after crop is planted but before it emerges and are of two kinds: (1) **contact pre-emergence**—an application made after weed emergence and (2) **residual pre-emergence** which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.
2. Soil sterilant. A material which renders the soil incapable of supporting plant growth. Sterilization may be temporary or relatively permanent.
3. **Contact herbicide.** An herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.
4. **Low volatility,** as applied to herbicides such as 2,4-D, 2,4,5-T and other similar compounds, is a relative term. Differences in volatility are real and important, but so far, can be determined only by biological tests.
5. **Low volatile esters.** The esters of 2,4-D, 2,4,5-T and other similar herbicidal compounds that have low volatility should not be designated as non-volatile esters.
6. **Spray drift.** The movement of airborne spray particles from the spray nozzle outside the intended contact area.
7. **Vapor drift.** The movement of herbicidal vapors from the area of application to adjacent areas.
8. **Rate and dosage.** These terms are synonymous. "Rate" is the preferred term. Rate refers to the amount of active material (such as 2,4-D acid equivalent) applied to a unit area (such as one acre) regardless of percentage of chemical in the carrier.
9. **Concentration.** Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of **pounds per unit volume of diluent.**
10. **Herbicide.** A chemical known to be toxic to some chlorophyll-bearing plants.
11. **Dormant treatment** of deciduous woody plants refers to applications of herbicides made during the period after leaf-fall, or death of leaves, and before bud-break.
12. **Basal treatment.** A basal treatment is an application to the stems of plants at and just above the ground line.
13. **Alphabetical designations** for chemical compounds should be capital letters (upper case) without spacing or periods; for example MCP, PCP.

ABBREVIATIONS

The use of the following abbreviations is recommended and, unless otherwise indicated, should be small letters (lower case) without spacing or periods:

acid equiv. per 100 gal. ....ahg	parts per million ....ppm
acre ....A	pint or pints ....pt
bushel or bushels....bu	pound or pounds ....lb
diameter ....diam	pounds per sq. in. ....psi
foot or feet ....ft	quart or quarts ....qt
feet per minute ....fpm	rate per acre .... ..gal/A, oz/A, lb/A, bu/A
gallon or gallons ....gal	revolutions per minute ....rpm
inch or inches ....in	square ....sq
miles per hour ....mph	weight ....wt

1955 Weed Essay Contest Winner

HOW WE CONTROL WEEDS ON OUR FARM

Jeanne Kievet, Lacombe, Alberta, Canada

When, in the spring of the year, a farmer sows his seed, he becomes a player in one of the biggest games of chance known to man. He has no way of knowing whether the odds are against him or in his favor, for Mother Nature guards her secrets well. She alone controls the moisture, the heat, the wind, the frost and the hail; she alone controls the disease and the insects. Thus, no amount of courage, planning or labor can change what nature has in store for the crops. But there is one factor which may spell success or failure for a farmer. This factor is the control of weeds. We, on our farm, are fighting a winning battle against weeds. It is an interesting story.

The district where our land is located is considered one of the best in central Alberta. This farm has been owned and operated by our family since 1910 when it was purchased by a brother of my grandfather. At that time there were only twenty acres broken. Between then and 1918 when my grandfather bought the farm, the entire acreage with the exception of two small two-acre clumps of brush and poplar had been put under cultivation. It had been a heavily wooded area and the virgin soil was rich and productive. There was no need then to guard against weeds. My grandfather finished clearing the land. He was a "straight grain farmer," and a good one. He saw the gradual onslaught of weeds as the years went by and did what he could to cope with the situation. He hand-pulled and burned the wild oats, the stinkweed and the mustard, and cut the thistle patches with the scythe. Because of economic pressure during the depression period he was unable to summer fallow as he wished to do, and feeling that there was no money in livestock, he cropped and recropped the fields year after year. These were the days of the threshing outfits, and in the fall, weeds were readily spread from one farm to another, by dirty separators and racks. Consequently, when my father took over the farm in 1943 there was a definite weed problem.

My father imigrated to Alberta from the Netherlands when he was sixteen. He knows the value of good land, and is proud of the privilege of being entrusted with a small portion of our great province. With him, farming is a business and his plans are made accordingly. He keeps abreast of the latest mechanical and chemical developments, and in close contact with our experimental station and our district agriculturist for the newest methods of weed control. He, realizing that the foundation of weed control rests on the practice of good farming methods, stresses crop rotation, which includes grasses and legumes. Furthermore he plants clean pure seed in a well prepared seedbed; controls weeds with chemicals; and takes precautions to check undue spread of weed seeds.

Our farm has now increased in size from the original half section to three quarters, and on this increased acreage straight grain farming is no longer the rule. This change in technique involves the raising and fattening of livestock. We have an average of seventy head and market approximately twenty each year. This necessitates using about one-hundred acres for grass and forage crops. These cultivated grass and forage crops compete sucessfully with annual weeds such as stinkweed, lambsquarter, shepherd's purse and common mustard, and also help to control perennials like Canada thistle or sow thistle by weakening their growth. When the time comes to return a plot to grain crops, it is plowed as soon as possible after the last hay crop has been harvested so that it can be cultivated for the remainder of the season.

The cattle also pasture on fields of sweet clover which are planted to provide nitrogen supply and organic matter which increases the density of the next

XUM

year's crop. The use of sweet clover as a nurse crop and the application of thirty-five pounds per acre of 11-48 ammonium phosphate at seeding time, result in faster growth and a much heavier stand of grain, which, in its turn, contributes greatly in controlling weeds by shading them and retarding their growth.

Manure in the feed lots of our fattening cattle is handled with the utmost care. It is allowed to go through a heat before being spread on the pasture land, so that any weeds which may be present are rendered sterile. Any manure which may contain wild oats is spread on grass land and it has been observed that these seeds lie on top of the grass and rot.

The wild oat is one of the biggest problems on our farm. This weed is kept in check and is gradually being eradicated by the following means. As late as possible before freeze-up or as early as possible in the spring, the ground is cultivated with a one way disc to a depth of two to two and one-half inches. This stimulates germination and the first growth of the weed is allowed to develop to a height of three to four inches. At this stage the field is tilled and an early maturing variety of grain such as Olli barley is sown immediately.

Another link in the chain of weed control is the use of pure clean seed which has a high germination count and will produce a quick vigorous growth. The farmer must be an ally of the grain crop in competing with the ever present community of weeds, and there is no surer way for him to assist than by using the best seed obtainable.

Weed control can be effective on a community basis, and it follows that control on neighoring farms lessens infestation on our own. For this reason we give our utmost support to the Seed Fair which stresses clean seed and weed control.

Summer fallow is now a regular part of our crop rotation. Weeds which grow from seeds must have their seeds germinated and the young plants killed, so tillage is planned to obtain the greatest possible germination by cultivation at different depths. This combats the annuals. Perennial weeds must be controlled by cultivation which starves the root system by preventing development of the leaves. A summer fallow plot must, therefore, be kept black during the growing season. This method has been used to practically eliminate couchgrass and perennial thistles from our land.

No wheat has been grown on this farm since 1938. We are located in the black soil zone of Central Alberta and we feel that weed control necessitates the elimination of wheat farming. Ours is a short growing period. This demands that wheat must be sown early, before there is any weed growth, to mature before frost. In order to delay seeding so that spring cultivation for weed seed germination and elimination of young weed seedlings may be exercised, we have switched to early maturing varieties of barley and oats.

During my grandfather's farming years, he fought a constant but losing battle against yellow mustard and stinkweed. Pulling bees, involving the entire family seemed to be a waste of time. These weeds were carried, it is believed by traveling threshing outfits. Each harvest season brought a fresh infestation. Now our harvesting is done with our own combine and trucks and there is no further reinfestation. We still have to keep constant vigilance against these pests but we have a new ally unknown to the past generation. It is the scientists' wonderful aid to the farmer—chemical weed control. We combat these annual weeds with 2,4-D and its intelligent use had reduced the mustard and stinkweed hazard to a minimum. Effectiveness depends on the concentration of the chemical and the kind, age and location of the weeds. Temperature, and the stage of maturity of the grain crop must also be taken into consideration.

Chemical weed control of a different sort has been used effectively to combat very small patches of toad flax and couchgrass. It is the application of sodium chlorate. This renders the area sterile for a year or more, but on extremely small patches it is preferred to cultivation because of the chance of dragging roots to other parts of the field.

Profiting from the experiences of my grandfather, my father had a strict rule to which he adheres. It is, "Never borrow implements which might be carriers of noxious weed seeds." Even enroute from one farm to another weed seeds might be picked up and carried onto our farm. If circumstances warrant the lending of any implement or rack, that piece of machinery is thoroughly cleaned before it reenters our fields. Should horses be at work on a neighbor's farm, they are kept in our barn for a period of time before being turned out again.

There has been wonderful progress during the last decade in development of power machinery, chemicals and general knowledge in the field of weed control. By the application of these things and with an understanding of the weed problem, and a sincere desire on the part of the farmer to master it, weeds **can** be controlled.

RESOLUTIONS

The following resolutions were passed by the Directors of the North Central Weed Control Conference which met in Omaha December 6th, 1955.

WHEREAS, the North Central Weed Control Conference has greatly enjoyed the excellent arrangements and facilities provided for holding this 12th Annual Conference: NOW, THEREFORE, BE IT RESOLVED that we express our appreciation to the State of Nebraska, the city of Omaha, the Omaha Chamber of Commerce, the Manager of the Fontenelle Hotel, the staffs of the Nebraska Department of Agriculture and the University of Nebraska, Mal Hansen, Farm Service Director WOW and WOWTV, Bill Macdonald, Farm Service Director, KFAB, and particularly to Dwight W. Lambert, Chairman of Local Arrangements, and to Neal E. Shafer, Chairman of the Program Committee, and to D. R. Weber representing Industry. We also wish to express our appreciation to Dayton L. Klingman, Chairman of the Research Committee for the Research Report along with the recommendations prepared by Mr. Cliff Elder.

FURTHERMORE, this conference wishes to express its appreciation to many other individuals and organizations who have helped to make this conference so successful. We want to express our thanks to the Midwest Farm Paper Unit for its attractive and well prepared program. We are grateful to Toastmaster Mr. George S. Round, Director of Public Relations, University of Nebraska, and the banquet speaker, Mr. Dave Livingston. We wish to thank Mr. Herb Plambeck, Farm News Editor, Radio Station WHO for giving us up to date information on Russian Agriculture.

WHEREAS, the North Central Weed Control Conference is always benefited by the fine exhibits: NOW, THEREFORE, BE IT RESOLVED that this conference express its sincere appreciation and thanks to those individuals responsible for the exhibits.

WHEREAS, the North Central Weed Control Conference has greatly benefited from work done by the U.S.D.A. Division of Weed Investigations, NOW, THEREFORE, BE IT RESOLVED that this conference commend the work of Dr. M. W. Parker, Head of the Weed Section of the Agricultural Research Administration in the research work of the U.S.D.A.

WHEREAS, the effectiveness of any weed control program is dependent upon the responses of plants: BE IT RESOLVED that the North Central Weed Control Conference encourage and support on a permanent basis, fundamental studies of the plants which are in any way related thereto.

WHEREAS, this is the 12th Anniversary of the establishment of the North Central Weed Control Conference, BE IT RESOLVED that the first resolution submitted at the first meeting November 16 and 17, 1944 be re-enacted:

> WHEREAS, the various states and interested groups working independently are unable to integrate the magnitude of the weed problems that menace the agriculture of this area:
> BE IT RESOLVED: that the North Central Weed Control Conference assembled at Omaha, Nebraska, November 16 and 17, 1944, believe that the Congress of the United States should provide adequate funds for the creation of a Weed Division in the United States Department of Agriculture. (The Weed Division has since been established.)
>
> 1. To coordinate a weed control program.
> 2. To conduct research on the methods of prevention and control of weed plants.
>
> BE IT FURTHER RESOLVED that the North Central Weed Control Conference cooperate with the Western Weed Control Conference in securing necessary legislation.

WHEREAS, heavy weed infestations are constantly occurring, and, WHEREAS one main source of these weed infestations is from screenings and other weed seed infested material: BE IT RESOLVED that in accordance with the wishes of the Regulatory Officials of this conference, the North Central Weed Control Conference urgently request the Congress of the United States to enact Federal Legislation regulating the movement of noxious weed seed infested screenings and other noxious weed seed infested material both into the United States and interstate. That the Secretary of the United States Department of Agriculture be requested to use his good offices to lend assistance to the state officials in their efforts to obtain this legislation. BE IT FURTHER RESOLVED that the Secretary of this conference be instructed to forward a copy of this resolution to the United States Secretary of Agriculture.

WHEREAS, federally owned and controlled lands are and are becoming more so infested with noxious weeds and whereas, these areas are a menace to other lands, private and public, and a handicap to state weed control officers in performing their duties, and WHEREAS, federal agencies frequently fail to cooperate with state laws: BE IT RESOLVED that Congress be memorialized to pass corrective legislation which will prevent federal agencies from violating state laws, particularly state weed laws.

WHEREAS, the passing of Alvin H. Larson of the University of Minnesota, the first Secretary-Treasurer and second Honorary Member of the North Central Weed Control Conference has deprived the entire weed control body of a man who had an intimate knowledge of plants out of place in the middle west. In the early days of our organization he was a familiar figure and his friendly and smiling countenance was known to all of the early workers. We will miss you Al: NOW, THEREFORE, BE IT RESOLVED that we express our heartfelt loss and extend our sympathy to his family.

WHEREAS, Professor Emil Korsmo of Oslo, Norway, the eminent weed authority of all Europe passed away since the last meeting of the North Central Weed Control Conference, NOW, THEREFORE, BE IT RESOLVED that we here assembled at Omaha on this 7th day of December 1955 express our loss at his departure. His recent book, "The Anatomy of Weeds," will be a living monument to a life wholly dedicated to the control of weeds.

May we rise and bow our heads in a moment of tribute to these men.

XUM

PRESENTATION OF AWARDS

I. Honorary Membership

Lyle A. Derscheid, Chairman of the Honorary Membership Committee of the North Central Weed Control Conference, Inc., made the following presentation of an Honorary Membership:

"It is my privilege to award this Honorary Membership to a man, who has long been active in weed control. He has been a leader in research and has been an inspiration to fellow workers. He has supervised the training of numerous graduate students, many of whom are doing outstanding work in various fields today.

He was born in Manhattan, Kansas, February 14, 1889, and obtained a Bachelor of Science degree at Kansas State College in 1908. He then obtained another Bachelor of Science degree in 1910 and a Master of Science degree in 1917—both at the University of Illinois. He then served as assistant professor of crops at Ohio State University. During this time he completed work for his Doctorate in 1926. He has served as Professor Agronomist in the Experiment Station since 1925.

He has been active in several organizations and is presently a member of American Society of Agronomy, American Society of Plant Physiologists, Soil Science Society of America, Ecological Society of America, and Weed Society of America. He served as Vice President and President of the American Society of Agronomy in 1953 and 1954, and has been honored as a fellow in that organization.

He is an authority on forage crops and was influential in converting sweet clover from the status of a weed to that of a valuable forage crop. He played an important part in moving alfalfa from the plains states east of the Mississippi River. He has done considerable work on root-top relationships in forage crops and other ecological problems; he has been interested in the physiology of legumes in humid areas and has studied many management problems.

Since Weed control was an integral part of forage crop production, he began his work over 30 years ago. Since that time he has published numerous papers concerning weed control, and he has guided numerous graduate students into the field.

As a result of his long standing interest in weed control, he was one of the original organizers of the North Central Weed Control Conference. He has served on the Research Committee every year, he was a member of the Board of Directors until recently, he was the first chairman of the old Policy Committee, and one of the first members of the Terminology Committee. He served as Vice President and President in 1947 and 1948. He served as Senior Scientist and Attache for the U.S. Department of State at the American Embassy in London during the summer of 1948.

It is impossible to enumerate all of his accomplishments in this short space of time, and I know that we have not mentioned all of them. It was just today that I learned that he was recently honored by Gamma Sigma Delta, National Honorary Agricultural Fraternity. He was awarded the Distinguished Service Award for Agriculture for 1955.

Because of his long time service and many contributions to weed control and the North Central Weed Control Conference, he is being awarded an Honorary Membership to the conference. It is my privilege and pleasure to present this honor in behalf of the North Central Weed Control Conference to Dr. Charles Julius Willard of Ohio State University."

II. Industry Awards

D. R. Weber, Chairman of the Industry Committee of the North Central Weed Control Conference, Inc., presented bronze plaques for outstanding weed control work at the county level to:

Henry W. Bless, Faribault County Weed and Seed Inspector, Wells, Minnesota who was selected as the outstanding county regulatory worker during 1955.

T. H. Young, Lawrence County Extension Agent, Spearfish, South Dakota, who was selected as the outstanding county extension worker for 1955.

XUM

REGISTRATION

1955 NORTH CENTRAL WEED CONTROL CONFERENCE, INC.

OMAHA, NEBRASKA

December 5, 6, 7, 8, 1955

A

Aanestad, Arden—DuPont & Co., 2005—7th St. N., Fargo, North Dakota
Abrahamson, Paul E. R., McCabe Co., 1113—4th St., Devils Lake, North Dakota
Adams, Stan—Pittsburgh Coke & Chemical Co., 3110 N. Fitzhugh, Dallas, Texas
Alban, Kenneth E.—Ohio State University, Columbus 10, Ohio
Allen, J. F.—Davey Tree Co., 105 West Lockwood Avenue, Webster Groves, Missouri
Allen, Wm. W.—American Chemical Paint Co., Butler Pike, Ambler, Pennsylvania
Alley, Harold—University of Wyoming, 1407 Spring Creek Drive, Laramie, Wyoming
Allington, Duane D.—Blue Springs, Nebraska
Alexander, Harold E.—Olin Mathieson Chemical Corp., 1236 So. 24th Street, Lincoln, Nebraska
Amos, Al—Port Huron Machinery & Supply Company—4300 Starr Street, Lincoln, Nebraska
Andersen, E. T.—University of Manitoba, 962 N. Drive, Winnipeg, Manitoba, Canada
Andersen, Robert N.—U.S.D.A. North Dakota Agricultural College, Fargo, North Dakota
Anderson, Clayton—Wakefield, Nebraska
Anderson, L. E.—Kansas State College, 770 Midland Avenue, Manhattan, Kansas
Anderson, Theo. J.—Clay Co., 1221—7th, Clay Center, Kansas
Anderson, R. E.—Buena Vista County, Linn Grove, Iowa
Anway, Hal—Monsanto Chemical Co., 4610 W 66th Ter., Kansas City, Missouri
Arbogast, E. A.—Monsanto Chemical Co., St. Louis, Missouri
Arnell, Arthur F.—Shell Chemical Corp., 1221 Locust, St. Louis, Missouri
Arthur, Dan—Boone County Weed District, Albion, Nebraska.

B

Bailey, Clarence—Decatur County, Oberlin, Kansas
Bakke, A. L.—Botany Hall, Iowa State College, Ames, Iowa
Balgley, Ely—Heyden Chemical Corp., 342 Madison Ave., New York
Bankston, E. W.—Farmers Union Central Exch., 912 West 3rd, Willmar, Minnesota
Barber, B. B.—The Broyhill Company, Dakota City, Nebraska
Barber, C. L.—Monsanto Chemical Co., 800 No. 12th, St. Louis, Missouri
Bardwell, C. M.—National Aluminate Corp., 2291 Fairfax St., Denver 7, Colorado
Barentson, M. P., Diamond Alkali Co., 4902 Capitol Avenue, Omaha, Nebraska
Barrett, W. L.—Consumers Co-Op Assn., 318 E. 10th, Kansas City, Missouri
Barrier, George E.—Iowa State College, 781 Pammel Court, Ames, Iowa
Barton, M. H.—Deere & Co., Moline, Illinois
Basore, Jim—Hobaugh & Marvin Agri. Chemicals—Box 731, Wichita, Kansas
Bayne, Ken—The Broyhill Co., Dakota City, Nebraska
Beatty, R. H.—American Chemical Paint Co.—243 Cronhill Road, Philadelphia 31, Pennsylvania
Beck, T. V.—Saskatchewan Dept. of Agriculture, Regina, Saskatchewan, Canada
Bell, W. C.—Frank Foundries Corp., 2020—3rd Ave., Moline, Illinois
Berggren, F. H.—Oldbury Chemical Co., 19 Rector St., New York, New York
Bever, Donald L.—Olin Mathieson Chemical Corp., 1620 "A" Street, Lincoln, Nebraska
Billings, E. M.—Monsanto Chemical Co., 300 N. 12th Blvd., St. Louis, Missouri
Birkley, Charles—Brown County, 712 Delaware, Hiawatha, Kansas
Birt, F. C.—Chipman Limited, 1040 Lynn Avenue, Winnipeg, Manitoba, Canada
Bjerken, Sig—Minnesota Dept. of Agriculture, 1907 Randolph Ave., St. Paul, Minnesota
Black, Donald T.—U.S.D.A., 2819 Kendale Dr., Toledo 6, Ohio
Blanchard, K. L.—Minnesota Dept. of Agriculture, 1385 Shryer Ave., St. Paul 13, Minnesota
Blaschko, Anthony—Buffalo County, Gibbon, Nebraska
Bless, Henry W.—Faribault County, Wells, Minnesota
Blondeau, Rene—Shell Development Co., P.O. Box 2171, Denver, Colorado
Boardman, S. L.—Greenwood County, Eureka, Kansas
Bohmont, Dale W.—Agronomy Dept., University of Wyoming, Laramie, Wyoming
Bohn, Harold H.—Hypro Engineering, Inc., 3612 Ingersoll, Des Moines, Iowa
Boss, Kenneth A.—Mutual Dealers Wholesale, Inc., 2361 Hampden, St. Paul 14, Minnesota
Bowman, C. C.—Shawnee County, 426 Ohio, Topeka, Kansas
Brandt, Chuck—The Farmer, 2241 Merrill, St. Paul, Minnesota
Branson, Harold A.—Standard Oil Co., 2310 W. 22nd St., Sioux Falls, South Dakota
Bray, Albert—Clark County, Ashland, Kansas
Brayton, Bert O.—Brayton Chemicals Inc., 2525 Cliff Rd., Burlington, Iowa
Breakey, W. J.—Dominion Experimental Farm, Morden, Manitoba, Canada
Breen, George—Thompson Hayward Chemical Co.,—4311 Maple, Omaha, Nebraska
Brichacek, Adolph—Colfax County, Clarkson, Nebraska.
Broderick, Martin—Allamakee County, Waukon, Iowa
Brookins, W. W.—Flax Development Committee, 262 Roanoke Building, Minneapolis 2, Minnesota
Brooks, Louis J.—Martin, South Dakota

XUM

Brown, G. R.—Miller Chemical Co., 9023 Jones St., Omaha, Nebraska
Brown, Warren C.—W. C. Brown Supply Co., 509—1st Ave. N., Ft. Dodge, Iowa
Broyhill, Roy F.—The Broyhill Company, Dakota City, Nebraska
Bruett, Charles—South Dakota Dept. of Agriculture, Pierre, South Dakota
Bruington, G. E.—Swift & Co., Plant Food Div., 522 Fitch, Chicago Heights, Illinois
Brummond, Kenneth E.—Thurston County, Rosalie, Nebraska
Brunn, Lynn K.—Atlas Powder Co., 7 Van Dyke Drive, Wilmington, Delaware
Bryant, Clyde A.—Dow Chemical Co., Route #1, Freeland, Michigan
Bryant, David E.—Wallace Farmer & Iowa Homestead, 1912 Grand Ave., Des Moines, Iowa
Buchholtz, K. P.—University of Wisconsin, Agronomy Dept., Madison, Wisconsin
Buechner, John R.—Hanson Equipment Co., 317 Hosmer, Rockford, Illinois
Buffinton, Guy—Crawford County, Denison, Iowa
Buhl, Alfred—Spraying Systems Co., 6635 Delmar Blvd., St. Louis 5, Missouri
Bulman, Alton J.—Allamakee County, Waukon, Iowa
Burg, Marlo—Burg Mfg. Co., Waverly, Nebraska
Burns, Dennis—Iowa Soda Products Co., 6660 Military Ave., Omaha, Nebraska
Bush, Dale A.—Nebraska Dept. Agriculture, 1816 Prospect St., Lincoln, Nebraska
Buskirk, G. C.—Pacific Coast Borax Co., 916 WOW Bldg., Omaha, Nebraska
Butler, Leland G.—Standard Agricultural Chemicals, Inc., 1301 Jefferson, Hoboken, New Jersey
Byerly, Wayne—Pioneer Hi-bred Corn Co., 1320 44th, Des Moines, Iowa
Byrnes, J. L.—Sedgwick County, 821 Porter, Wichita. Kansas

C

Cada, B. A.—Colfax County, Clarkson, Nebraska
Cady, Corl—5316 York Ave. S., Minneapolis, Minnesota
Caldwell, Julian—Thompson Hayward Chemical Co., 5651 Miami St., Omaha, Nebraska
Cameron, J. F.—Green County, Scranton, Iowa
Campbell, Jack A.—California Packing Corp., 714 11th St., Rochelle, Illinois
Campbell, L. C.—Campbell Mfg. Co., Walthill, Nebraska
Carnes, A. H.—Pittsburgh Coke & Chemical Co., 75 E. Wacker Drive, Chicago, Illinois
Carroll, John E.—Hypro Engineering, Inc., 7509 Sheridan Ave. S., Minneapolis, Minnesota
Carroll, John V.—Riverdale Chemical Co., 2650 Noble Ave. N., Minneapolis, Minnesota
Catherwood, James J.—J. C. Robinson Seed Co., Waterloo, Nebraska
Chambers, R. H.—Pioneer Chemical Co., Inc., Box 432, 510-514 E. Front, North Platte, Nebraska
Champman, H. W.—University of Nebraska, 3344 Dudley St., Lincoln, Nebraska
Chandler, Edw. L.—Diamond Alkali Co., 428 E. Walnut, Painesville, Ohio
Chapp, Donald F.—Swift & Co., 845 E. 56th S., Chicago 37, Illinois
Chenik, Dick—Stauffer Chemical Co., 204 Howard St., Ames, Iowa
Chisholm, Dan—American Chemical Paint Co., 258 Woody Drive, Jackson, Mississippi
Chittenden, Dudley B.—Dow Chemical Co., 315 Lynn Ave., Ames, Iowa
Christopher, Albert W.—Wright County, Eagle Grove, Iowa
Christopher, Lester L.—Winru Packaging, Inc., 62 So. James St., Kansas City, Kansas
Clark, Dale E.—Central Popcorn Co., Box 184, Schaller, Iowa
Clark, Dana A.—Diamond Black Leaf, 3525 Vandalie Rd., Des Moines, Iowa
Clarke, Gilmore—Nemaha County, Auburn, Nebraska
Cloud, R. P.—Spencer Plant Foods Inc., Spencer, Iowa
Clover, Clarence—Bean Division, 112 First Ave. E., Flandreau, South Dakota
Coffey, Walker—A.T.&T. Co., 324 E. 11th, Kansas City, Missouri
Cole, Kenneth G.—K. G. Cole Chemicals, Inc., 945 Feldkamp, Springfield, Illinois
Cooke, Anson R.—Dept. of Botany, Oklahoma A&M College, Stillwater, Oklahoma
Coon, Edward T.—Dow Chemical Co., 3614 Lancaster, Midland, Michigan
Copenhafer, L. M.—Kansas Highway Dept., 3806 West 12, Topeka, Kansas
Copenhaver, Ralph—Thurston County, Walthill, Nebraska
Corbin, W. L.—Dow Chemical Co., 135 South LaSalle St., Chicago 3, Illinois
Corcoran, Leo T.—Boone County, St. Edward, Nebraska
Cottier, E. F.—Pacific Coast Borax Co., 224 Opelika Road, Auburn, Alabama
Coulter, L. L.—Dow Chemical Co., 4415 Chatham Drive, Midland, Michigan
Counter, Bertha—York County, York, Nebraska
Counter, Tom—York County, York, Nebraska
Cox, Edwin W.—W. T. Cox Co., 1015 Walnut, Kansas City 6, Missouri
Creasy, R. C.—Pittsburgh Coke & Chemical, 322 N. Sarah St., St. Louis 8, Missouri
Cree, Robert V.—Thompson Hayard Chemical Co., 2912 West 72nd St., Prairie Village, Kansas
Criswell, Robert J.—National Aluminate Corp., 5230 E. Jewell Avenue, Denver 22, Colorado
Crockett, Edgar—84th & Dodge, Omaha, Nebraska
Crowell, Cecil—Webster County, 545 W. 5th Avenue, Red Cloud, Nebraska

D

Damon, E. W.—Standard Oil Co., 1520 N.E. Pkwy., Wichita, Kansas
Dana, Malcolm N.—University of Wisconsin, Dept. of Horticulture, Madison, Wisconsin.

Registration List (Continued)

Davenport, R. E.—Hoard's Dairyman, Fort Atkinson, Wisconsin
Davidson, Harold E.—Gresen Mfg. Co., 2888 Webster St., Omaha, Nebraska
Davis, Frank J.—Miller Chemical Co., 15th & California, Omaha, Nebraska
Davis, Larry—Penn. Salt Mfg. Co., 721 E. Lombard, Springfield, Missouri
Davis, V. H.—Farm Bureau Coop. Assn., 245 N. High St., Columbus, Ohio
Day, H. M.—Geigy Agr. Chemicals, 154 Tooker Ave., Springfield, New Jersey
Dean, Roy—Dow Chemical Co., 7810 Blandford Drive, Normandy 21, Missouri
DeGarmo, Oliver—Monsanto Chemical Co., 400 Claybrook Lane, Kirkwood 22, Missouri
Denisen, Ervin L.—Dept. of Horticulture, Iowa State College, Ames, Iowa
Derscheid, Lyle A.—South Dakota State College, Agronomy Dept., Brookings, South Dakota
Deuser, Ralph—M.F.A. Oil Co., 11 S. 7th St., Columbia, Missouri
Dibble, William J.—Pacific Coast Borax Co., 630 Shatto Place, Los Angeles, California
Dickison, Fred F.—U.S. Dept. of Interior, 3613 Himebaugh Ave., Omaha 11, Nebraska
Dodge, Harold—Shell Chemical, 1620 Claudine Drive, St. Louis 15, Missouri
Dodson, Chas.—Frontier County, Maywood, Nebraska
Doll, C. C.—Iowa State College, Council Bluffs, Iowa
Doran, Cliff—Elsco Inc., 315 24th St., Rock Island, Illinois
Dorfman, Edwin—Hooker Electro Chemical Co., Niagara Falls, New York
Doryland, Thomas—University of Nebraska, 3800 North 48th, Lincoln, Nebraska
Dosch, Fred M.—Pacific Coast Borax Co., 4010 Washington St., Kansas City, Missouri
Douglas, Richard W.—Woodbury Chemical Co., 702 S. 4th St., St. Joseph, Missouri
Dreessen, Jack—Natl. Agri. Chemicals Assn., 1145 19th Street, N.W., Washington, D. C.
Dunham, Ray S.—University of Minnesota, Institute of Agri., St. Paul 1, Minnesota
Dutton, W. C.—The Dow Chemical Co., Midland, Michigan

E

Eastwood, John P.—Velsicol Chemical Corp., 700 Kellogg Ave., Ames, Iowa
Eckert, E. C.—Michigan State Highway Dept., Stevens T. Mason Bldg., Lansing, Michigan
Eigenberg, Ray R.—Crete Mills, 318 Ivy, Crete, Nebraska
Elliott, Irwin C.—Pittsburgh Coke & Chemical Co., 301 W. Main St.. Littleton, Colorado
Elge, Elton—Elge Flying Service, Aurora, Nebraska
Elwell, Harry M.—Box 465, Weed Section, ARS-USDA, Guthrie, Oklahoma
Esch, Ed—Red Willow County, Indianola, Nebraska
Euting, Neil A.—Midwest Aquatic Nuisance Control Co., 704 Elizabeth, Oconomowoc, Wisconsin
Evans, Arlyn W.—DuPont & Co., 1207 Foshay Tower, Minneapolis, Minnesota
Everett, Leonard R.—Woodbury Chemical Co., 217 No. 20th, St. Joseph, Missouri

F

Faas, Lee D.—Pioneer Hi-Bred, 5734 Lincoln, Des Moines, Iowa
Fagot, G. W.—Dawson County, 211 East 8th, Lexington, Nebraska
Fall, Ted—Penn. Salt Mfg. Co., 4716 Broadway, Indianapolis, Indiana
Farnam, Art—General Hydraulics, 301 Charles St., South Beloit, Illinois
Feldman, H. W.—U. S. Rubber, Bethany 15, Connecticut
Fellman, John A.—General Chemical Division, 12260 South Carondolet Ave., Chicago 33, Illinois
Fensler, Robert K.—The Nebraska Farmer, 1315 South 27th, Lincoln, Nebraska
Fiffe, Art—Cloud County, 533 E. 6th St., Concordia, Kansas
Finch, Burl—Thompson Hayward Chemical Co., 909 2nd St. S., Minneapolis, Minnesota
Fine, Homer—The Nebraska Farmer, Rt. 1, Roca, Nebraska
Finnegan, H. T.—Riley Bros., Inc., 512 Columbia, Burlington, Iowa
Fitzgerald, Ray—Thompson Hayward Chemical Co., S.W. 1st & Granger, Des Moines, Iowa
Fletchall, O. Hale—University of Missouri, 108 Waters Hall, Columbia, Missouri
Flint, George W.—Standard Oil Co., RFD #1, Homewood, Illinois
Foeppel, William—The Farr Co., Greeley, Colorado
Follier, Emmett—863 So. English, Marshall, Missouri
Fortmeyer, Darle F.—Hawkeye Spraying Service Inc., Goodland, Kansas
Fosse, Dick—American Chemical Paint Co., 50 So. Chase Dr., Denver, Colorado
Foster, J. Roe—Exp. Farm, Canada Dept. of Agriculture, Indian Head, Saskatchewan, Canada
Fox, W. B.—Chipman Limited, 1040 Lynn Ave., Winnipeg, Manitoba, Canada
Franz, A. J. (Andy)—Pittsburgh Coke & Chem. Co., 322 N. Sarah St., St. Louis 8, Missouri
Friesen, George—University of Manitoba, 1008 Weatherdon Ave., Winnipeg, Manitoba, Canada
Friesen, H. A.—Dept of Agriculture, Lacombe, Alberta, Canada
Froh, Milo D.—Farmrite Sprayer Inc., 618 Anne Street, Oconomowoc, Wisconsin
Frolik, E. F.—Agri. Exp. Sta., University of Nebraska, Lincoln, Nebraska
Fuchs, Albert F.—Diamond Alkali Co., 2436 Fenwich Rd., Cleveland 18, Ohio
Fulcher, C. J.—Sac County, Sac City, Iowa
Furby, Tom—Boone County, Albion, Nebraska
Furrer, J. D.—Agronomy Dept., College of Agriculture, Lincoln, Nebraska

XUM

Fuxa, Ray—Miller Chemical Co., Omaha, Nebraska

G

Garmhausen, W. J.—State Highway Dept., 450 E. Town St., Columbus, Oiho
Garrett, De Ross—Carroll County, 115 E. 5th, Carroll, Iowa
Gates, Charles M.—Diamond Black Leaf Co., 5311 Halsey Ct., Louisville, Kentucky
Gawtry, Bob—Diamond Blackleaf Co., 1716 Franklin Ave., Des Moines, Iowa
Geise, Charles E.—California Packing Corp., 124 Ave. D, Rochelle, Illinois
Gerdes, Richard—Diamond Black Leaf Co., 6204 Windsor, Des Moines, Iowa
Gerdes, Richard—Diamond Black Leaf Co., 6204 Windsor, Des Moines, Iowa
Gibson, John W.—Dow Chemical Co., 2541 Cashion Place, Oklahoma City, Oklahoma
Gilbert, Chas. J.—State Weed Board, 725 2nd St., Brookings South Dakota
Gladstone, Arthur M.—Nopco Chemical Co.—164 Mill Lane, Mountainside, New Jersey
Gleason, Lowell S.—Rockefeller Foundation, Londres 45, Mexico, D.F., Mexico
Glenn, James L.—Equip. Lubricants & Supply Co., 315-24 St., Rock Island, Illinois
Glissmann, Lee H.—Turf Grass Nursery, 92 Neptune Place, Omaha 10, Nebraska
Goetze, Norman—Purdue University, 12-4 Ross Ade Drive, W., Lafayette, Indiana
Gorman, John J.—Floyd County, Charles City, Iowa
Gowland, Joseph—Pacific Coast Borax Co., R.R. #3, Valparaiso, Indiana
Graves, Harold—Hart Equipment Co., Rockton, Illinois
Gray, James—Reasor-Hill Corp., Rt. #1, Jacksonville, Arkansas
Graznak, Michael—M.F.A. Oil Co., 11 So. 8th St., Columbia, Missouri
Greenwood, Archie—Cheyenne County, Dalton, Nebraska
Gress, Jerry L.—Selco Sup. Co., Severance, Colorado
Grigsby, Buford H.—Dept. of Botany, Michigan State University, East Lansing, Michigan
Grisham, Charles L.—Monsanto Chemical Co., 800 North 12th, St. Louis, Missouri
Gullikson, Glenn—Dow Chemical Co., 602 E. Ashman, Midland, Michigan
Gunkelman, John L.—R. F. Gunkleman & Sons, 1009 10th St. S., Fargo, North Dakota
Guth, D. O.—Guth Products Co., 7828 Sunset Drive, Elmwood Park 35, Illinois

H

Hagood, Edward S.—Niagara Chemical Div., Middleport, New York
Hahn, Lloyd—Hahn, Inc., 1825 W. Franklin St., Evansville, Indiana
Hall, William F.—Chipman Chem. Co. In., Bound Brook, New Jersey
Halvorson, Richard—Farmers Union State Exchange, 4260 Douglas St., Omaha, Nebraska
Hamilton, Robert H.—U.S.D.A., 317 Haag Ct., East Lansing, Michigan
Hamm, Philip C.—Monsanto Chemical Co., 729 Yale, Webster Groves, Missouri
Hamsher, C. A.—General Chemical Div., 40 Rector Street, New York 6, New York
Hanna, Chas.—Quad City Air Service, 1302 39th St., Moline, Illinois
Hannah, Charles P.—Jefferson County, Oskaloosa, Kansas
Hannah, Lawrence H.—Monsanto Chemical Co., 800 N. 12th Blvd., St. Louis 1, Missouri
Hansen, Henry L.—University of Minnesota, 1466 Grantham, St. Paul, Minnesota
Hansen, Mal—Meredith WOW, INC., Insurance Bldg., Omaha, Nebraska
Hansen, William—Nebraska Division of Noxious Weeds, Lincoln, Nebraska
Hanson, Glenn—Hanson Equipment Co., Box 270. Beloit, Wisconsin
Hanson, H. C.—Hanson Equipment Co., Box 270, Beloit, Wisconsin
Hanway, Donald G.—Agronomy Dept., College of Agriculture, Lincoln, Nebraska
Harper, George—Elsco Inc., 315 24th St., Rock Island, Illinois
Harriman, Eddie—Farmers Union State Exch., 2410 Ave. A., Council Bluffs, Iowa
Harshbarger, Harold L.—Acme Chemical Co., 3761 "D" Street, Lincoln, Nebraska
Hart, Richard David—Purdue University, 1 Univ. Street W., Lafayette, Indiana
Hart, W. H.—Hart Equipment Co., P.O. Box 575, Rockton, Illinois
Haskell, Tison—Geigy Ag. Chemicals, 125 Charles St., Geneva, Illinois
Havelka, Joe—Sherman County, Loup City. Nebraska
Hawke, John H.—Shell Chemical Corp., 1221 Locust Street, St. Louis, Missouri
Hay, James R.—Central Experimental Farm, Ottawa, Canada
Heath, Gene—Marion County, 323 Locust, Marion, Kansas
Heikes, Gene—Montana Extension Service, Bozeman, Montana
Helgeson, F. A.—Agri. Exp. Station, 1452 12th St. N., Fargo, North Dakota
Hemphill, Delbert D.—Dept. of Horticulture, University of Missouri, Columbia, Missouri
Henry, J. E.—Agri. Exp. Sta., 1190 Schrock Road, Columbus, Ohio
Hepperly, A. K.—Burlington Lines. C. A. Johnson Bldg., Denver, Colorado
Herr, Donald—Iowa Soda Products Co., 3311 Forest Lawn, Omaha, Nebraska
Herrett, Richard A.—University of Minnesota, 2089 Carter Ave., St. Paul, Minnesota
Herrod, Thomas E.—Agri. Aviation Services, Inc., 410 Calif. Blvd., Denver, Colorado
Herron, J. W.—University of Kentucky, 349 Holly Hill Dr., Lexington, Kentucky
Hickey, Tom—The Nebraska Farmer, 1420 "P" Street, Lincoln, Nebraska
Higbee, F. Farrell—Brown Farm Chemical Co., Box 517 Scottsbluff, Nebraska
Hill, Lyle O.—Reasor-Hill Corp., Jacksonville, Arkansas
Hilt,J. R.—Comanche County, Wilmore, Kansas
Hilton, James L.—Iowa State College, 525 Welch, Ames, Iowa
Hinz, Robert W.—American Chemical Paint Co., Route #4, Box 144, Excelsior, Minnesota

Registration List (Continued)

Hobaugh, Carl F.—Hobaugh & Marvin Agri. Chemicals, P.O. Box 731, Wichita 1, Kansas
Hoffman, R. J.—Miller Chemical Co., 5103 Cuming St., Omaha, Nebraska
Hofman, D. G.—Birds Eye Div. General Foods Corp., 108—6th Ave. N.W., Waseco, Minnesota
Hokanson, H.—Roberts County, 209 E. Ash St., Sisseton, South Dakota
Holaday, Ken—Pittsburgh Coke & Chemical Co., 75 E. Wacker Drive, Chicago, Illinois
Holdeman, Ralph K.—Chase County, 521 Oak, Cottonwood Falls, Kansas
Holen, Walter F.—W. H. Barber Co., 825 S.E. Thornton, Minneapolis, Minnesota
Hollenbeck, Carlos—Quick Supply Co., 530 Euclid Ave., Des Moines, Iowa
Hollingsworth, Clarence A.—Greenwood County, Eureka, Kansas
Holm, LeRoy G.—Dept. of Horticulture, University of Wisconsin, Madison, Wisconsin
Holub, F. Wm.—Black Hawk County, Hudson, Iowa
Honma, Shigemi—845 North 44th, Lincoln, Nebraska
Hope, Raymond—Pottawatomie County, Westmoreland, Kansas
Hopkins, Bob—The Nebraska Farmer, Lincoln, Nebraska
Horacek, John E.—Nance County, Fullerton, Nebraska
Horak, Jos.—Colfax County, Clarkson, Nebraska
Horne, Don—Chipman Chemical Co., 1005—1st St. N., Fargo, North Dakota
Horst, Elmer W.—Cowley County, 921 E. 19th Street, Winfield, Kansas
Hotz, Robert—Hanson Equipment Co., Beloit, Wisconsin
Houborg, Alfred—Dawson County, Cozad, Nebraska
Howard, Harold H.—Thompson-Hayward Chemical Co., 2915 S.W. Blvd., Kansas City 8, Missouri
Howden, John S.—Sherwin-Williams Co., 100 Princess St., Winnipeg, Manitoba, Canada
Huckstep, E. F.—General Chemical Div., 1221 Locust St., St. Louis 3, Missouri
Hudson, George E.—Hudson Chemical Co., 12336 Clayton Rd., St. Louis, Missouri
Hughes, Wm. J.—Shell Development Co., 1129 Mills Ave., Modesto, California
Hult, Pere—Olin Mathieson Chemical Corp., Burlington, Iowa
Hunt, Walter A.—Kansas Board of Agriculture, R.R. #2, Arkansas City, Kansas
Hurley, Dunlea—Gray & Rogers Public Relation Agency, Newhope, Pennsylvania
Hutchison, Earl—Scotts Bluff County, 1822 Ave. "G", Scottsbluff, Nebraska
Hutchison, John L.—Kansas State Board of Agriculture, Paradise, Kansas
Hyde, Tom—Harvey County, Halstead, Kansas
Hyland, J. A.—Pacific Coast Borax Co., 2295 Lumber Street, Chicago 16, Illinois
Hyle, Eldon L.—Oldbury Electro-Chemical Co., 1029 Winfield, Topeka, Kansas
Hyry, Edmund—Associated Sales & Supply Co., 5137 Southwest Ave., St. Louis, Missouri

I

Ilisulu, Koimul—University of Turkey, 3257 Holdrege, Lincoln, Nebraska
Inman, Wallace D.—Capper's Farmer, 912 Kansas Avenue, Topeka, Kansas

J

Jacobson, Eldon H.—Minnesota Farm Bureau Ser. Co., 101 E. Fairfield Ave., St. Paul, Minnesota
Jarnagin, Johnnie—Wayne Feed Store, Lexington, Nebraska
Jeffers, William A.—Davey Tree Expert Co., 1028 Jessie Avenue, Kent, Ohio
Jenkins, B. C.—Michigan Dept. of Conservation, 813 Ann St., East Lansing, Michigan
Jennish, R. W.—Hypro Engineering Inc., 726 WOW Bldg., Omaha, Nebraska
Jensen, Edwin H.—University of Minnesota, 1229 Rose Vista Ct., St. Paul, Minnesota
Johnson, A. K.—Delavan Mfg. Co., 811-4th St., West Des Moines, Iowa
Johnson, Byron G.—University of Wisconsin, 204 North Brooks St., Madison, Wisconsin
Johnson, Norman—Skelly Oil Co., 3711 Aurora Drive, Omaha, Nebraska
Johnson, Virgil M.—Johnson Seed Service, 3342 Duncan St., St. Joseph, Missouri
Johnston, G. A.—Equip. Lubricants & Supply Co., 315—24th St., Rock Island, Illinois
Jones, Warren—Agri. Services, Inc., 402 Flour Exchange, Minneapolis, Minnesota
Josephs, Melvin J.—Dow Chemical Co., c/o Bldg. 47, Midland, Michigan

K

Karlovetz, Fred—Chemi-Trol Chemical Co., Rt. 1, Gibsonburg, Ohio
Kauffman, Ralph—Asplundh Tree Expert Co., 505 York Rd., Jenkintown, Pennsylvania
Kazium, Dr. Bayrahbar—University of Turkey, North 38th Street, Lincoln, Nebraska
Keaton, Ken—Niagara Chemical Div., Wymore, Nebraska
Keena, J. L.—Stauffer Chemical Co., 901 E. Ellsworth, Salina, Kansas
Keene, Robert E.—Delavan Mfg. Co., 811—45th St., West Des Moines, Iowa
Kelly, Paul F.—Niagara Chemical Div., 1641—3rd Ave., N.E., Rochester, Minnesota
Kennedy, W. C.—Thompson Hayward Chemical Co., 4523 Poppleton, Omaha, Nebraska
Kerr, Cecil F.—Chipman Chemical Co., 2708 Garfield, Bay City, Michigan
Kerr, Harold Delbert—U.S.D.A.-A.R.S., 706 L Univ. Village, Columbia, Missouri
Keyser, H. R.—Experiment Station, 311 North Elm, North Platte, Nebraska
King, L. J.—Boyce Thompson Institute, 1086 N. Broadway, Yonkers, New York

XUM

Registration List (Continued)

Kircher, W. H.—The Farmer, 55 E. 10th St., St. Paul 2, Minnesota
Kitt, John J.—Dundy County, Benkelman, Nebraska
Klatt, W. L.—Pacific Coast Borax Co., 859 Quari St., Denver 8, Colorado
Klingman, Dayton L.—U.S.D.A.-A.R.S., 108 Waters Hall, Columbia, Missouri
Knaus, R. J.—Mackwin County, Winona, Minnesota
Knowlan, Jack H.—Stauffer Chemical Co., 2805 Bloomfield, Cape Girardeau, Missouri
Koch, Frank J.—Lincoln County, R.F.D., Hershey, Nebraska
Kolpin, Normond V.—Chipman Chemical Co., 735 Laurel St., St. Paul, Minnesota
Kommedahl, Thor—University of Minnesota, 1840 W. Roselawn Ave., St. Paul 13, Minnesota
Krekow, Herbert F.—Cherokee County—514 No. 9th, Cherokee, Iowa
Kress, Richard—Illinois State Highway Dept., 164 DuPage St., Elgin, Illinois
Kroeber, John K.—U.S. Forest Service, 623 No. Second Street, Milwaukee, Wisconsin
Kroger, John, Jr.—Thurston County, Rosalie, Nebraska
Kruse, Geo. C.—Hart Equipment Co., P.O. Box 575, Rockton, Illinois
Kruse, Otto—Martin County, Fairmont, Minnesota
Kullberg, George—Webster County, Fort Dodge, Iowa
Kumpost, Henry E.—Thurston County, Walthill, Nebraska

L

Lair, Howard—Selco Supply Co., Eaton, Colorado
Lambert, Dwight W.—Noxious Weed Division, Lincoln, Nebraska
Lana, E. P.—1126 Grand, Ames, Iowa
Land, J. A.—Union Pacific Railroad, 4903 California, Omaha, Nebraska
Lantz, H. L.—Horticulture Dept., Iowa State College, Ames, Iowa
Larson, Joe L.—Wright County, Clarion, Iowa
Larson, Russell E.—U.S.D.A., 1608 Anthony, Columbia, Missouri
Lauritsen, Andrew—Cuming County, West Point, Nebraska
LaVelle, H. S.—Skelly Oil Co., 4627 Penn., Apt. 1, Kansas City, Missouri
Laverty, Chuck—Laverty Seed Farms, Indianola, Iowa
Lawrence, Geo. A.—Diamond Black Leaf, 1237 No. 5th St., Fargo, North Dakota
Lee, Oliver C.—Purdue University, 220 Littleton St. W., Lafayette, Indiana
Lemmon, Raymond—Chipman Chemical Co., 2511 North 66th Avenue, Omaha, Nebraska
Levenson, Ethel N.—Levenson Chemical Co., 1407 Harney, Omaha, Nebraska
Lindaberry, Harold—Penn Salt Mfg. Co., 723 New York, Aurora, Illinois
Liljedahl, Louis A.—U.S.D.A., 4137—31st Avenue South, Minneapolis 6, Minnesota
Lloyd, Ralph R., Jr.—Olin Mathieson Chemical Corp., Box 991, Little Rock, Arkansas
Longtin, Edward J.—Minnesota Dept. of Conservation, 115 Lincoln Avenue, White Bear Lake, Minn.
Loomis, W. E.—Iowa State College—426 Welch Ave., Ames, Iowa
Loustalot, A. J.—Office of Experiment Stations, 3165 N. 21st St., Arlington 1, Virginia
Luebke, Norm—Hanson Equipment Co., Beloit, Wisconsin
Lueking, L. S.—Harlan County, Atlanta, Nebraska

M

MacDonald, Bruce C.—General Chemical Div., 2020 Broadway N.E., Minneapolis 13, Minnesota
MacMullan, Ralph A.—Dept. of Cons., Houghton Lake, Michigan
Madjer, J. Edward—Wyandotte County, 447 Fowler St., Kansas City, Kansas
Marantz, B. B.—Interprovincial Coop Ltd., Ste 10—172 Centennial St., Winnipeg, Canada
Marshall, Ernest R.—G. L. F. Soil Bldg. Service, Ithaca, New York
Martin, Dr. D. C.—General Chemical Div., 511 East Patterson, Kalamazoo, Michigan
Marvin, Philip H.—Hobaugh & Marvin Agri. Chemicals, 303 N. Juliette, Manhattan, Kansas
Mason, Max K.—Thompson Hayward Chemical Co., 1110 South 4th, Omaha, Nebraska
Mathias, John S.—Private Brands, Inc., 4618 Warwick Blvd., Kansas City, Missouri
Mathis, L. Alfred—Nebraska Seed Division, 2121 So. 52nd St., Lincoln, Nebraska
Matthews, Dick—McCool Air Service, McCool Junction, Nebraska
May, Russell—Spraying Systems Co., 6635 Delmar, St. Louis, Missouri
May, Walter P.—Crete Mills, 2001 Holly Road, Lincoln, Nebraska
McCall, George L.—Dupont & Co., 3 Stockwell Road, Wilmington 3, Delaware
McCallum, Duncan—Chipman Chemical Co., 608 South Dearborn Street, Chicago, Illinois
McCarty, M. K.—A.R.S.-U.S.D.A., 3626 Everett, Lincoln, Nebraska
McClure, Charles P.—W. H. Barber Co., 6841 Garfield So., Minneapolis, Minnesota
McFadden, Tom—Sherman County, Loup City, Nebraska
McKinley, I. S.—R. C. Hill Farm Management Co., 635 Grain Exchange Bldg., Omaha, Nebraska
McLane, H. R.—Private Brands, Inc., 5810 Beverly, Mission, Kansas
Melander, L. W.—American Chemical Paint Co., 1439 Hythe St., St. Paul 8, Minnesota
Meliz, Harold R.—Consumers Coop. Assn., 318 East 10th Street, Kansas City, Missouri
Mercer, Marc E.—Spraying Systems Co., Milwaukee, Wisconsin
Mercer, Richard W.—Buffalo County, Rt. #4, Box 458, Kearney, Nebraska
Mickelson, Stewart A.—Black Hills Ord. Depot. Igloo, South Dakota
Milbrath, Mel—Midland Cooperatives Inc., 739 Johnson St. N.E., Minneapolis, Minnesota

Miller, Raburn Gray—Laverty Seed Farms, 209 South First, Indianola, Iowa
Miller, Ray—Kansas State Highway Dept., 121 W. 21st St., Topeka, Kansas
Milton, Carleton R.—Better Homes & Gardens, 601 W. Jackson Blvd., Chicago, Illinois
Minsky, Isadore—Reade Mfg. Co., Inc., 135 Hoboken Avenue, Jersey City, New Jersey
Mobberley, David G.—Laverty Seed Farms, 901 North C., Indianola, Iowa
Monson, Warren G.—University of Nebraska, 1736 Harwood, Lincoln, Nebraska
Moore, Don—Farmrite Sprayer Inc.,606 S. 8th St., Watertown, Wisconsin
Moore, Glenn D.—Northrup, King & Co., 4007—61st Ave. N., Minneapolis, Minnesota
Moorehead, F. G.—Ida County, 410 Moorehead, Ida Grove, Iowa
Morgan, Edwin—Dakota County, South Sioux City, Nebraska
Morris, W. B.—Grain Belt Chemical Co., 6510 Edgevale Road, Kansas City, Missouri
Mozer, Phillip C.—Export Chemical Corp. of Colorado, 1590 W. 12th Ave., Denver, Colorado
Munderloh, Robert—Cuming County, Beemer, Nebraska
Munroe, William L.—W. A. Munroe & Son, 926 S. Claussen. Grand Island, Nebraska
Myers, Edward J.—Diamond Alkali Co., 2112 Carroll Ave., St. Paul, Minnesota

N

Nash, Russel L.—South Dakota State College, 1328—3rd St., Brookings, South Dakota
Naylor, J. E.—DuPont & Co., 502 Ivydale Rd., Wilmington, Delaware
Nellor, Harry A.—Cuming County, Beemer, Nebraska
Nelson, Andrew L.—Audubon County, Exira, Iowa
Nelson, Chas. E., Jr.—DuPont & Co., 1205 Prudential Bldg., Houston, Texas
Nelson, Doug—Niagara Chemical Div., 2203 West Oklahoma, Grand Island, Nebraska
Nelson, Russell T.—The Great Western Sugar Co., Longmont, Colorado
Neve, Leland—Benton Co., 605 E. 8th, Vinton, Iowa
Newlin, Owen—Pioneer Hi-Bred Corn Co., Johnston, Iowa
Nicholas, Syd S.—Thermoid Co., 4924 Emerson So., Minneapolis, Minnesota
Nordgren, R. E.—1025 Turner Blvd., Omaha 5, Nebraska
Northrop, Ray—Planetary Chemical Co., 10439 Sappington Lane, St. Louis 23, Missouri
Nylund, Robert E.—University of Minnesota, 1480 Raymond Ave., St. Paul 8, Minnesota

O

Oberts, David G.—Green Giant Co., N. Spring, Beaver Dam, Wisconsin
Ogilvy, F. R.—Pacific Coast Borax Co., 916 WOW Bldg., Omaha, Nebraska
Ohle, Lester C.—Geigy Chemical Co., 2431 Otis Street, Denver, Colorado
Ohmstede, Chris—Webster County, Guide Rock, Nebraska
Olcott, Robert—Monsanto Chemical Co., 1335—39th, Des Moines, Iowa
Olien, Andrew—Minnesota Dept. of Agriculture, 711—4th St., S.W., Waseca, Minnesota
Olson, H. C.—DuPont & Co., 3514 Ernst, Omaha, Nebraska
Olson, Tom—Thermoid Co., 2018 So. Halsted St., Chicago, Illinois
Olson, P. J.—Grafton, North Dakota
Owen, George H.—Wisconsin Agriculture (Farm Press), 1912 Grand, Des Moines, Iowa
Oyloe, Orville—Farmers Union Grain & Supply, Williston, North Dakota

P

Palmer, S. J.—Wallace Farmer, 1912 Grand Avenue, Des Moines, Iowa
Pankaskie, Joe E.—Shell Development, 3520 Magnolia, Denver, Colorado
Parker, Marion W.—U.S.D.A.-A.R.S., Plant Industry Station, Beltsville, Maryland
Parris, Cleston G.—Assn. of American R.R.'s, 3140 S. Federal St., Chicago 16, Illinois
Pass, Herbert A.—Sherwin-Williams Co., 2875 Centre St., Montreal, Quebec, Canada
Patton, Royce—Aerial Weed Control Co., Goodland, Kansas
Pauli, Ray—Farmrite Sprayer, Inc., 1422—9th St., Watertown, Wisconsin
Pauli, Verle—Farmrite Sprayer, Inc., 1214 Center, Watertown, Wisconsin
Pavlychenko, Thomas K.—American Chem. Paint Co., 1024 Osler Street, Saskatoon, Saskatchewan, Canada
Pearson, Baxter—Monsanto Chemical Co., 900 Blossom Lane, Rock Hill 19, Missouri
Peebler, Ralph V.—Capper's Farmer, 912 Kansas Ave., Topeka, Kansas
Petersen, Merle—The Tractor Stilts Co., 7205 Lawndale Drive, Omaha, Nebraska
Peterson, Don—Agronomy Department, University of Wisconsin, Madison, Wisconsin
Petty, C. G.—Lincoln County, 802 W. 9th, North Platte, Nebraska
Phillips, W. M.—U.S.D.A.-A.R.S., 2105 Canal Blvd., Hays, Kansas
Pike, Gilbert A.—Van Pelt Laboratories, 1630-35th St., Denver, Colorado
Pintke, Irv.—901 Mohawk Lane, St. Joseph, Michigan
Pipal, F. J.—World Herald, 1515 No. Happy Hollow Blvd., Omaha, Nebraska
Ploeg, H. L.—DuPont Co., 1207 Foshay Tower, Minneapolis 2, Minnesota
Pokorny, Walter—Colfax County, Howells, Nebraska
Polite, Jack—Diamond Alkali Co., 345 N. Main St., Chagrin Falls, Ohio
Possehl, Fred L.—Reading Chemical & Equipment Co., 120 B Ave. N.E., Cedar Rapids, Iowa
Powers, Frank C.—Spencer Plant Foods, 24 Peterson Drive, Storm Lake, Iowa
Priebe, Clarence—Kossuth County, 208 South Heckart St., Algona, Iowa
Putnam, D. H.—Butler County, Court House, Eldorado, Kansas

XUM

Q

Queen, M. L.—Hypro Engineering, Inc., 61 Glenston, Dexter, Missouri
Quick, F. J.—Chamberlain Corp., Voffins, Div., 1815 Walnut, Cedar Falls, Iowa

R

Rae, Robert B.—State Weed Office, Brookings, South Dakota
Ragan, Howard A.—Birds Eye Div. Gen Foods Corp., 121 7th Street N.W., Waseca, Minnesota
Ragsdale, O.M.—Standard Oil Co., 111 State, Ames, Iowa
Rake, D. W.—Pacific Coast Borax Co., 630 Shatto Pl., Los Angeles 5, California
Ramirez, Adriana—Ministerio de Agriculture, Casilla 5577, Santiago, Chile
Rasmussen, D. L.—John Bean Div., Reinbeck, Iowa
Rasmussen, Roy—Boys Town, Omaha, Nebraska
Rasmussen, T. D.—Scotts Bluff County, Rt. 2, Mitchell, Nebraska
Rathke, Chris E.—Dawson County, 1408 N. Jackson, Lexington, Nebraska
Rav, Leroy W.—Brown Farm Chemical Co., Box 517, Scottsbluff, Nebraska
Raven, A. O.—Emulsol Chemical Corp., 59 E. Madison, Chicago, Illinois
Reade, Richard—Mid-Continent Aerial Sprayers, Inc., Hayti, Missouri
Reading, A. J.—Chipman Chemical Co., 608 South Dearborn St., Chicago 5, Illinois
Reading, Larry—Reading Chemical & Equipment Co., 120 B Ave. N.E., Cedar Rapids, Iowa
Reed, Frank—Spraying Systems Co., 1408—1st Ave S., Minneapolis, Minnesota
Reed, H. C.—Slayton, Minnesota
Reed, J. Harley—Iowa Dept. of Agriculture, 1308—1st, Boone, Iowa
Reed, Leslie R.—Chipman Chemical Co., Inc., Boundbrook, New Jersey
Reichert, D. D.—Monsanto Chemical Co., 5746—1st Ave. S., Minneapolis, Minnesota
Reid, John R.—Tama County, Tama, Iowa
Reimer, C. A.—Dow Chemical Co., 225 Broadway, South Haven, Michigan
Riggs, E. C.—Lennox Furnace Co., 1701 E. Euclid Avenue, Des Moines, Iowa
Rogers, Bruce J.—Purdue University, 102 E. Oak, W. Lafayette, Indiana
Rogers, Donald E. A.—D. & R.G.W. Railroad, 2905 Chase, Denver 14, Colorado
Rogers, James F.—N. S. Koos & Son, Co., 506 No. Dryden Ave., Arlington Heights, Illinois
Rogers, John J.—Iowa Farm Supply Co., 700—22nd St., W. Des Moines, Iowa
Rohwer, George—Washington County, Ft. Calhoun, Nebraska
Rollings, Clair T.—U. S. Fish & Wildlife Service, 620 Upton Ave. S., Minneapolis, Minnesota
Rose, Franklin—Kansas State Highway Dept., 1206 High Ave., Topeka, Kansas
Ross, Donald R.—Graham & Ross Jobbers, Box 1805, Great Falls, Montana
Rotramel, Jack G.—Monsanto Chemical Co., Box 322, Shawnee, Kansas
Ruge, John—Thurston County—Emerson, Nebraska
Russell, Monte—Lawrence Co., Spearfish, South Dakota

S

Sadler, David A.—World Herald, 4215 Emmet, Omaha, Nebraska
Salmonson, Gordon S.—Penn. Salt Mfg. Co., 2212—10th Ave. N., Grand Forks, North Dakota
Sand, P. F.—Agronomy Dept., University of Nebraska, Lincoln, Nebraska
Sanderson, E. G.—South Dakota State Weed Board, Aurora, South Dakota
Schaap, Otto C.—Mutual Dealers Wholesale, 5215 Elliot Ave. S., Minneapolis, Minnesota
Schachterle, Dean—Bureau of Reclamation, 715 Westridge Pkwy., McCook, Nebraska
Schick, John N.—Olin-Mathieson Chemical Corp., 1414 Burr, Lincoln, Nebraska
Schieferstein, Robert H., Iowa State College, 782 Pammel Court, Ames, Iowa
Schmidt, Henry G.—Thayer County, Deshler, Nebraska
Schmierer, E. H.—Pacific Coast Borax Co., 4010 Washington, Kansas City, Missouri
Schoenherr, Wm. H.—The Crete Mills, Crete, Nebraska
Schrage, G. H.—Swift & Co., Red Oak, Iowa
Schuller, John P.—Stauffer Chemical Co., Columbus, Nebraska
Schulte, Ralph—Pocahontas County, Palmer, Iowa
Schutte, Wayne M.—Overton Chemical Sales, Sumner, Iowa
Scott, Maynard W.—Kansas Noxious Weed Division, 808 Main Ave., Larned, Kansas
Seabury, R. F.—American Cyanamid Co., 618—16th St., Ames, Iowa
Sears, C. A.—American Cyanamide Co., 30 Rockefeller Plaza, New York, New York
Sexsmith, J. J.—Canada Dept. of Agriculture, 950—20th Street South, Lethbridge, Alberta, Canada
Shafer, Neal E.—Agronomy Dept., University of Nebraska
Shankland, Dan L.—Stauffer Chemical Co., 511 S. Kilbourn, Chicago, Illinois
Shannon, Gail—Atchison County, Muscotah, Kansas
Shatwell, Wm. E.—Hqs. 5th Army, 803 Meadow Lane, Barrington, Illinois
Shebeski, L. H.—University of Manitoba, 581 Campbell St., Winnipeg, Manitoba, Canada
Shelley, Wallace G.—Allied Eng. & Mfg. Co., 70 So. 12th St., Minneapolis, Minnesota
Shepard, Ralph L.—Pisgah, Iowa
Sherman, Alwin C.—Monsanto Canada Ltd., 1550 Rand Ave., Vancouver 14, B. C., Canada
Sherwood, Frank—American Chemical Paint Co., 3816 W. 55th St., Minneapolis, Minnesota

Sherwood, Lloyd V.—Monsanto Chemical Co., 800 N. 12th Blvd., St. Louis, Missouri
Shirley, Jim—General Chemical Div., 1221 Locust, St. Louis, Missouri
Siebert, Everett, Walworth County, Selby, South Dakota
Sieck, Ardell—Nebraska Seed Division, 1710 Connie Rd., Lincoln, Nebraska
Simonsen, Dr. D. W.—Simonsen Mill, Quimby, Iowa
Sitter, Matt—Mackwin Chemical Co., 1084—2nd, Des Plaines, Illinois
Slabo, Steve S.—University of Wiconsin, 15 N. Bassett St., Madison, Wisconsin
Slaughter, Ray E.—The Dakota Farmer, 1200 Main, Aberdeen, South Dakota
Slife, Fred W.—Agronomy Dept., University of Illinois, Urbana, Illinois
Smith, Harlen E.—Pueblo Chemical Co., 1219 East 11th St., Pueblo, Colorado
Smith, Harold G.—Auburn, Nebraska
Smith, L. H.—Cottonwood County, 1125 River Road, Windom, Minnesota
Smith, Paul—Lennox Furnace Co., 3519 E. 36th Ct., Des Moines, Iowa
Smith, W. H.—Polk County, 1965 Walker, Des Moines, Iowa
Smith, Walter L.—American Chemical Paint Co., 515 West Blvd South, Columbia, Missouri
Smith, Walton A.—Riverdale Chemical Co., 324 E. 147 St., Harvey, Illinois
Snyder, Darl E.—Standard Oil Co., 910 S. Michigan Avenue, Chicago, Illinois
Soderdahl, Paul—Guth Products Co., 525 N. Humphrey Ave., Oak Park, Illinois
Soderholm, Robert—Solderholm Mfg. Co., Route 1, Worthington, Minnesota
Spackman, Everett W.—Wyoming Dept. of Agriculture, Cheyenne, Wyoming
Spargur, William B.—Delavan Mfg. Co., 811—4th St., West Des Moines, Iowa
Splets, Al—Associated Producers, Inc., LeSueur, Minnesota
Spradling, Stuart L.—M.F.A. Oil Co., 514 S. Williams, Columbia, Missouri
Sprinkle, G. E.—Russell County, Dorrance, Kansas
Stahler, L. M.—Pacific Coast Borax Co., 630 Shatto Place, Los Angeles, California
Stamm, John J.—Penn. Salt Chemicals, 309 Graham Bldg., Aurora, Illinois
Stanford, John P.—Oldbury Electro-Chemical Co., 562 E. Northside Dr., Jackson. Mississippi
Staniforth, David W.—Botany Dept., Iowa State College, Ames, Iowa
Stastny, Robert—Thayer County, Alexandria, Nebraska
Stearns, Forest—Dept. of Botany & Plant Pathology, Purdue University, Lafayette, Ind.
Steier, Elmer J.—Steier Flying Service, Whittemore, Iowa
Sterling, G. R.—Alta Dept. of Agric., Parl. Bldg., Edmonton, Alberta, Canada
Stern, Walter C.—Planetary Chemical Co., 11693 Manchester Rd., St. Louis, Missouri
Steudel, Herman L.—Reade Mfg. Co., 9500 Cottage Grove Ave., Chicago 28, Illinois
Stewart, Sam F.—Pittsburgh Coke & Chemical Co., 75 E. Wacker Dr., Chicago, Illinois
Stitt, Loyd L.—Velsicol Chemical Corp., 321 W. Prairie Ave., Wheaton., Illinois
Stoller, John—Red Willow County, Indianola, Nebraska
Stone, E. C.—E. C. Stone Co., 136 W. 12th Avenue, Denver, Colorado
Stone, James—Pacific Coast Borax Co., 630 Shatto Place, Los Angeles, California
Stower, C. E.—1519 Murray Ave., Worthington, Minnesota
Strand, Art—St. Thomas, North Dakota
Stucky, H. E.—McPherson County, McPherson, Kansas
Stull, Aaron K.—Carbide & Carbon Chemical Co., 30 E. 42nd St., New York, New York
Sundell, Carl—Wayne County, Wakefield, Nebraska
Swingle, M. C.—DuPont & Co., 1204 Evergreen Rd., Wilmington, Delaware
Swink, Hugh—Pittsburgh Coke & Chemical Co., 3110 N. Fitzhugh, Dallas, Texas
Sylwester, E. P.—Iowa State College, 2928 Ross Rd., Ames, Iowa

T

Tafuro, Anthony—American Chemical Paint Co., 1280 Nolen Road, Roslyn, Pennsylvania
Taylor, George E.—U. S. Rubber Co., 1230—6th Ave., New York 20, New York
Taylor, Jack P.—American Chemical Paint Co., Ambler, Pennsylvania
Taylor, Roscoe L.—Alaska Experiment Station, Palmer, Alaska
Temple, Melvin—Pioneer Hi-Bred Corn Co., 4040 Wallace Lane, Des Moines, Iowa
Thomas, Ralph—Tri-States Co., 119 East Washington Ave., Madison 3, Wisconsin
Thomas, Warren—Webster County, Red Cloud, Nebraska
Thomsen, Norman D.—Diamond Back Leaf Co., 4324 W. 36th St., Minneapolis, Minnesota
Thompson, Wm. T.—Thompson Chemicals Corp, 3028 Locust, St. Louis, Missouri
Torkelson, O. J.—Fargo Foundry Co., 1217—4th St. N., Fargo, North Dakota
Torpy, Lawrence D.—Torpy Tree Service, 1146 South 87th, Omaha, Nebraska
Tremain, Lawrence W.—Colfax County, 716 Gold Street, Schuyler, Nebraska
Troph, Charles L.—Diamond Alkali Co., 20 North Wacker Dr., Chicago, Illinois
Turner, Max B.—Woodbury Chemical Co., Box 336, Sioux Falls, South Dakota

U

Ullrich, Dick—Thermoid Co., Box 356, Grinnell, Iowa

V

Vail, Glenn, Riley County, 1009 Poyntz, Manhattan, Kansas
Vanicek, Rudy—Colfax County, R.F.D., Schulyer, Nebraska
Van DeWalle, Frank—Boone County, Cedar Rapids, Nebraska
Van Geluwe, John—F.L.F., Terrace Hill, Ithaca, New York

XUM

Registration List (Continued)

Van Patten, Loyd H.—Iowa Dept. of Agriculture, 807 E. Salem, Indianola, Iowa
Van Scoik, W. S.—American Cyanamid Co., 1018 Maxine Drive, Fort Wayne, Indiana
Van Skike, Kenneth R.—Pacific Coast Borax Co., 1708 Haeg Drive, Minneapolis 20, Minnesota
Van Zanden, Tom—U.S.D.A. Plant Pest Control, 2339 Valentine, St. Paul 8, Minnesota
Varner, Reed W.—DuPont & Co., 1116 N. Hilton Road, Wilmington, Delaware
Viehmeyer, Glenn—North Platte Experiment Station, North Platte, Nebraska
Vogel, M. A.—Stauffer Chemical Co., P.O. Box 434, Yakima, Washington
Von Hofsten, Carl Gustaf—Fed. of Swedish Farmers Assn., Havsfruvagen 12, Bromma, Stockholm, Sweden
Vortman, Adolph—Thayer County, Box 11, Deshler, Nebraska
Vosler, Floyd—Indian Hills Golf Course, 87th & Cass, Omaha, Nebraska

W

Wagner, R. L.—Fertilizer & Chemical Supply, Hartington, Nebraska
Wallace, Keith—South Dakota State College, 804—6th Ave., Brookings, South Dakota
Wallberg, John H.—Dow Chemical Co., 135 S. LaSalle St., Chicago 3, Illinois
Walter, Clarence—Dawson County, Eddyville, Nebraska
Walworth, Bryant L.—American Cyanamid Co., 4 Warner Dr., Noroton Heights, Connecticut
Walz, Arnold W.—American Chemical Paint Co., 4001 Orleans Ave., Sioux City, Iowa
Wangerin, Robert R.—Monsanto Chemical Co., 800 N. 12th St., St. Louis 1, Missouri
Ward, Merle E.—DuPont of Canada, 80 Richmond St. West, Toronto, Ontario, Canada
Warden, Robert L.—Dow Chemical Co., 9257 West 22nd St., Minneapolis, Minnesota
Warne, M. L.—Warne Chemical & Equipment Co., 1733 West Rapid St., Rapid City, South Dakota
Warren, Charles W.—Park Dept., 605 City Hall, Omaha, Nebraska
Warren, G. F.—Dept. of Horticulture, Purdue University, Lafayette, Indiana
Warren, L. F.—Buffalo County, 201 West 31st, Kearney, Nebraska
Watson, W. D.—DuPont of Canada, 294 Portage Ave., Winnipeg 12, Manitoba, Canada
Weber, Donald R.—Spraying Systems Co., 3201 Randolph St., Bellwood, Illinois
Weber Walter—Indiana Farm Bureau Coop., 47 S. Penn., Indianapolis, Indiana
Welch, J. R.—American Chemical Paint Co., 2503 Robinwood Lane, Denton, Texas
Welker, William—University of Wisconsin, 205 N. Midvale Blvd., Madison, Wisconsin
Wenger, Otto E.—U. S. Rubber Co., 2638 North Pulaski, Chicago, Illinois
Werner, H. O.—University of Nebraska, 3310 Dudley St., Lincoln, Nebraska
West, R. B.—Tryco Mfg. Co., 4 Ridge Avenue, Decatur, Illinois
Whelan, Louis—St. Thomas, North Dakota
Whinfrey, C. G.—Penn. Salt Chemicals, 309 Graham Bldg., Aurora, Illinois
White, Kels—Collier Chemical Co., Richmond, Missouri
Widdifield, R. B.—North Dakota State College, 1041 Oak St., Fargo, North Dakota
Wiese, Allen F.—Amarillo Experiment Station, Bushland, Texas
Wilkens, John—Dundy County, Benkelman, Nebraska
Willard, Charles J.—H & F Bldg., Ohio State University, Columbus 10, Ohio
Williams, N. Coburn—University of Illinois, 300 S. Goodwin, Urbana, Illinois
Williams, P. L.—Stauffer Chemical Co., P.O. Box 222, So. Omaha Station, Omaha, Nebraska
Wilson, Robert G.—Nemaha County, Auburn, Nebraska
Wirth, J. F.—Hypro Engineering, Inc., 700—39th Ave., N.E., Minneapolis, Minnesota
Witman, E. D.—Columbia So. Chemical Corp., One Gateway Center, Pittsburgh, Pennsylvania
Woestemeyer, Vernon W.—Kansas Noxious Weed Division, R.R. #5, Topeka, Kansas
Wolcott, Art—Farmers Union Central Exchange, 1137 Ave F, Billings, Montana
Wolf, Robert F.—Wolf Bros. & Reich, Albion, Nebraska
Wood, H. E.—Dept. of Agriculture, 711 Fisher St., Winnipeg, Manitoba, Canada
Woofter, H. D.—Pittsburgh Coke & Chemical Co., 224 Hays Rd., Bridgeville, Pennsylvania
Wormley, George W.—Farm Journal, 6620 Sprague St., Philadelphia 19, Pennsylvania
Worthington, G. F.—Spraying Systems Co., 617 Davis, Evanston, Illinois
Woyahn, Jerry—General Chemical, 3357 W. 47th Pl., Chicago, Illinois
Wright, Walter—Iowa County, Belle Plaine, Iowa

Y

Yahnke, Burdette—Green Giant Co., LeSueur, Minnesota
Yapp, Don—Sprayrite Service Co., 1308—9th Ave., Belle Plaine, Iowa
Yero, Richard J.—Libby, McNeill & Libby, 13636 S. Western Ave., Blue Island, Illinois
Young, Claude L.—Consumers Co-Op Association, 2545 "Q," Lincoln, Nebraska
Young, T. H.—Lawrence County, Spearfish, South Dakota
Younghein, John E.—Skyways, Inc., 1001 Norfolk Avenue, Norfolk, Nebraska
Youngman, Vern—University of Nebraska, 1628 No. 31st, Lincoln, Nebraska

Z

Zedler, Robert J.—Carbide & Carbon Chemical Co., 30 E. 42nd St., New York 17, New York
Zick, Warren H.—University of Wisconsin, Madison, Wisconsin
Zimmerman, George—South Dakota Weed Board, 4115 Pleasant Dr., Rapid City, South Dakota
Zimmerman, Hugo J.—Colfax County, Schuyler, Nebraska
Zinter, Clinton C.—F. H. Peavey & Co., 912 Grain Exchange, Minneapolis, Minnesota
Zorsch, C. P.—Monsanto Chemical Co., 800 N. 12th Street, St. Louis 1, Missouri

LIST OF MEMBER COMMERCIAL ORGANIZATIONS

as of November 16, 1955

American Chemical Paint Company	Ambler, Pennsylvania
Agricultural Spraying & Equipment Company	Reinbeck, Iowa
Brown Farm Chemical Company	Scottsbluff, Nebraska
The Broyhill Company	Dakota City, Nebraska
Chipman Chemical Company	Bound Brook, New Jersey
Clark Manufacturing Company	Independence, Missouri
Delavan Manufacturing Company	W. Des Moines, Iowa
Dow Chemical Company	Midland, Michigan
E. I. DuPont de Nemours & Company, Inc.	Wilmington, Delaware
Fargo Foundry	Fargo, North Dakota
Farmrite Sprayer, Inc.	Clyman, Wisconsin
Food Machinery & Chemical Company	Lansing 4, Michigan
Geigy Chemical Corporation	Des Moines, Iowa
General Hydraulics Corporation	Beloit, Wisconsin
Hahn, Inc.	Evansville, Indiana
Hanson Chemical Equipment Company	5, Beloit, Wisconsin
Hobaugh & Marvin	Wichita, Kansas
Hypro Engineering, Inc.	Minneapolis 12, Minnesota
Illinois Farm Supply Company	Chicago 11, Illinois
Miller Chemical Company, Inc.	Omaha, Nebraska
Monsanto Chemical Company	St. Louis, Missouri
Mutual Dealers Wholesale, Inc.	St. Paul 14, Minnesota
Naugatuck Chemical	Naugatuck, Connecticut
National Grain Company, Ltd.	Winnipeg, Canada
Niagara Chemical Company	Middleport, New York
Oberdorfer Foundries, Inc.	Syracuse, New York
Oldbury Electro-Chemical Company	New York 6, New York
Pacific Coast Borax Company	Los Angeles 5, California
F. H. Peavey & Company	Minneapolis 15, Minnesota
Pittsburgh Coke & Chemical Company	Pittsburgh 30, Pennsylvania
Private Brands, Inc.	Kansas City 18, Kansas
Reade Manufacturing Company	Jersey City, New Jersey
Riverdale Chemical Company	Harvey, Illinois
J. C. Robinson Seed Company	Waterloo, Nebraska
Standard Agricultural Chemicals, Inc.	Hoboken, New Jersey
Spraying Systems Company	Bellwood, Illinois
Standard Oil Company	Chicago 80, Illinois
Thompson Chemicals Corporation	St. Louis 3, Missouri
Thompson Hayward Chemical Company	Kansas City, Missouri
Tryco Manufacturing Company	Decatur, Illinois
Tri-State Milling Company	Rapid City, South Dakota
Woodbury Chemical Company	St. Joseph, Missouri

XUM

LIST OF EXHIBITORS

American Chemical Paint Company	Ambler, Pennsylvania
Broyhill Company, The	Dakota City, Nebraska
Burg Manufacturing Company	Waverly, Nebraska
California-Spray-Chemical Corporation	Richmond, California
Campbell Manufacturing Company	Walthill, Nebraska
Carbide & Carbon Chemicals Company	Long Island City, New York
Chipman Chemical Company, Inc.	Bound Brook, New Jersey
Consumers Cooperative Association	Kansas City, Missouri
Delevan Manufacturing Company	West Des Moinest, Iowa
Diamond Alkali Company	Cleveland 14, Ohio
Diamond Black Leaf Company	Cleveland 14, Ohio
Dow Chemical Company	Midland, Michigan
E. I. DuPont DeNemours & Co., Inc.	Wilmington 98, Delaware
Geigy Chemical Company	Des Moines, Iowa
General Chemical Division	
Allied Chemical & Dye Corporation	New York 6, New York
G &G Manufacturing Company	Omaha, Nebraska
General Hydraulics Corporation	South Beloit, Illinois
Hanson Equipment Company	Beloit, Wisconsin
Hart Equipment Company	Rockton, Illinois
Hypro Engineering, Inc.	Minneapolis 21, Minnesota
John Bean Division	
Food Machinery & Chemical Corporation	Lansing 4, Michigan
John Deere Plow Company	Omaha, Nebraska
Miller Chemical Company	Omaha, Nebraska
Monsanto Chemical Company	St. Louis 4, Missouri
Oldbury Electro-Chemical Co.	New York 6, New York
Olin Mathieson Chemical Corp.	St. Louis 2, Missouri
Pacific Coast Borax Company	Los Angeles 5, California
Pennsylvania Salt Mfg. Co. of Washington	Aurora, Illinois
Pittsburgh Coke & Chemical Company	Pittsburgh 19, Pennsylvania
Port Huron Machinery & Supply Company	Lincoln, Nebraska
PowerAire Equipment Company	Omaha, Nebraska
Riverdale Chemical Company	Harvey, Illinois
Spraying Systems Company	St. Louis 5, Missouri
Stauffer Chemical Company	Chicago 1, Illinois
Thompson-Hayward Chemical Company	Kansas City 8, Missouri
Tractor Stilts Company, The	Omaha, Nebraska
United States Rubber Company	New York 20, New York

XUM

XUM

XUM

XUM